Chapter 4: Mining Background and Mining Scenario

In late May 2012 EPA published for public comment, an assessment of the Bristol Bay watershed and southwest Alaska. The document is intended to help EPA understand how future large-scale mining may affect the Bay's valuable fishery resources, particularly its salmon fishery. It is titled *Assessment of the Potential Mining Impacts on Salmon Ecosystems of Bristol Bay, Alaska.*

Of the 5,522[1] on-time comments postmarked by July 23, 2012, a total of 319 letters were submitted by commenters other than the general public, 2,177 comments were submitted by individuals from the general public, and 29 mass mailing campaigns were sponsored by a number of organizations. The remaining letters are from mass mailing campaigns. In addition, EPA held eight public hearings, for which transcripts were developed. This document provides a compendium of the technical comments related to mining background and the mining scenario.

[1] In addition, the docket counted approximately 225,000 mass comment letters that were not posted individually.

a. KNOWN MINERALS DEPOSITS

Alaska Department of Natural Resources (Doc. #4818.3)

- *Section 4, Page 4-2*
  - *Comment:* Table 4-1 shows significantly lower grades of ore than that reported in the 2011 Report done for Dynasty Minerals by Wardrop. For example, copper % grade is reported as 0.34% in the Bristol Bay Watershed Assessment while the Waldrop states it is from 0.38% for the small mine and 0.46% for the full mine. This is significant since it relates to the economics of the project. Gold is also reported in the Bristol Bay Watershed Assessment as 0.31 grams per ton while the Waldrop report has it as 0.36 grams per ton.
  - *Recommended Change:* The potential range of grades for the deposit should be reported in this table. (p. 30)
- *Section 4.1.2, Page 4-4*
  - *Comment:* EPA states, "…there are limitations in our ability to make predictions with a high level of certainty because of the inherent complexity of natural materials and their environment." EPA then goes on to compare the Pebble deposit to the Bingham Canyon deposit in Utah, and unilaterally make significant and substantial assumptions and predictions about physical settings, features and impacts of mining in the Bristol Bay region. (p. 30)
- *Section 4.1.2, Page 4-4*
  - *Comment*: It is inappropriate to start the Environmental Chemistry section with a statement that mining can pose a risk. This approach is repeated throughout the document, putting a conclusive statement in the introduction to a section, and then only discussing generally how the stated impact occurs. Because of this, the Bristol Bay Watershed Assessment seems to be trying to influence readers without any substantiation.

    The limitations on the ability to quantify releases to the environment should be discussed in detail in the Uncertainty Assessment if not elsewhere.

    Recommended Change: Change structure of sections with an introduction to the issues, present data that is available and that is not, conclude what can be surmised from the data, and describe what the data gaps exist and what can and can't be concluded. (p. 31)
- *Section 4, Page 4-4 to 4-7*
  - *Comment:* Considerable narrative is presented on the hypothetical chemistry of the porphyry copper deposits, discussing how the acid generation potential (AP), the net neutralization potential (NP) and the neutralizing potential ratio (NPP) are calculated and what they mean. On page 4-5, it is stated that "In general, the rocks associated with porphyry copper deposits tend to straddle the boundary between being net acidic and net alkaline, as illustrated by Borden (2003) for the Bingham Canyon, Utah porphyry copper deposit (Figures 4-2 and 4-3). This is good information but the specific AP, NP and NPP of the Pebble Deposit are not discussed here. This is crucial information since it has bearing on potential environmental impacts during the mine and after the mine life in perpetuity. Good information on the humidity cell tests of the Tertiary and Pre-Tertiary waste rocks are included in Table 4 on page 15 of Appendix H. This information is more valuable than the extensive hypothetical discussion and should be incorporated into pages

4-4 through 4-7.
  - *Recommended Change:* Place the information from Appendix H (in summary form) on pages 4-4 through 4-7. (p. 31)

Alaska Miners Association, Inc. (Doc. #4612.2)
- EPA Data. EPA's Assessment comes to a similar conclusion. Table 4-1 on page 4-2 of the Assessment compares Pebble to other copper porphyry deposits. The table shows that Pebble's tonnage is over 7 times greater than the 90th percentile of global copper porphyry deposits. EPA concludes that "The well-delineated Pebble deposit is clearly at the upper end of the total size range; any additional deposits found in the Nushagak River and Kvichak River watersheds would be expected to be one or two orders of magnitude smaller" (p. 17-18)

J.P. Tangen (Doc. #4583.1)
- Copper Porphyry deposits are not representative of the mineral deposits in the Bristol Bay watershed. There are other significant deposits in the area that have been documented by BLM and the USGS as well as a number of undiscovered deposits USGS deems probable. Their analyses estimate that there is 50% probability that there are 14 non-copper-porphyry deposits within the watershed. (p. 1)

Sheila Wehmeyer (Doc. #3486)
- In section 4.3.2 the draft Assessment notes that if Pebble were "fully mined … may exceed 11 billion metric tons of ore…". The 11Bt noted by Ghaffari and used here by the EPA is the total resource – not the mineable, economic reserve. (p. 3)
- Suggest that low tonnage deposits are low grade as well (table 4.1), revealing unfamiliarity with porphyry projects globally. (p. 4)

b. Mining Process Associated with Copper Mining

Alaska Department of Natural Resources (Doc. #4818.2 and 4818.3)
- EPA states that the mine scenarios described in the Assessment reflect "current good, but not necessarily best, mining practices" for porphyry copper mining. Therefore, the assumptions made by the EPA based on "good practices" may not reflect the "best practices" that may be used by an actual mining operation or that may be required by state or federal regulatory agencies through the permitting process for a large mine. This approach is unrealistic considering the amount of scrutiny expected from the public and the requirements of the regulatory agencies that issue permits and approvals for mines in Alaska. (Doc. #4818.2 , p. 4)
- *Section 4, Page 4-8 to 4-11*
  - *Comment:* The following comment is an example of how possible mitigation methods could reduce the level of environmental concern and significantly alter the conclusions of impact if the mine plan used in the assessment had been vetted through the environmental and permitting review processes.
    The referenced pages discuss the processing operation, but only in brief detail. The

Northern Dynasty Minerals, Ltd. Report of 2011 was used to supplement this information. The accuracy of this report in representing PLP current plans is unknown, but this report does provide details and specifics that would be expected from a submitted mining project proposal. From pages 4-8 through 4-11 and pages 164 through 174 in the Northern Dynasty Minerals, Ltd. Report of 2011, a prospective plan is to grind the ore to 80% passing 200 μmeters and produce rougher tailings which are basically inert and are approximately 85% of the total ore feed. The remaining 15% goes to another grinding circuit where the material will be ground to 80% passing 30 μmeters. There will then be various recovery flotation units for copper, molybdenum, etc. Gold will also be recovered. Of the 15% that is reground, 14% will be pyritic tailings that will be over 50% to 80% pure pyrite. This material will be encapsulated in the TSFs to prevent (or retard) oxidation and thus the production of sulfuric acid and dissolution of metals. As a potential mitigation measure, PLP should consider modifying the processing mill to get full recovery of the pyrite and place none of it in the TSFs. It is fully recognized that this major change would require a full evaluation but it is based on the following reasons: 1) Page 173 of the Northern Dynasty Minerals, Ltd. report shows that considerable gold is locked up in solid solution with the pyrite and additional grinding of the pyrite produces significantly better recoveries of gold; 2) the pyrite could potentially be oxidized by bio-leaching, roasting and other methods; 3) if the site produces nearly 1 billion tons of pyritic tailings over the life of the mine, a reasonable estimate of iron content of these tailings is 25%. This is 250 million tons of iron. When this project was first evaluated, iron's value was $50 per ton. It is now $160 per ton and has no sign of easing, due to the growth in China and India. This value is $4 billion and although the cost of this recovery is expensive, this value would help offset it; 4) substantial savings in the design of liners in the TSFs could be realized since all of the material in the TSFs would be inert and there is no compelling reason to spend large sums in stopping seepage for water quality reasons; 5) large sums could also be saved in water treatment for decades and possibly centuries since treatment may not be needed of the seepage water. Pumping costs from seepage ponds could also be saved; 6) since the iron would be sold, the overall size of the TSFs could be reduced by approximately 10-12%, saving additional sums of money in dam construction; and 7) offering this change could help in easing permitting costs and addressing a major concern of water quality from the TSFs would be eliminated.
This is not to say that this must be done; it may not be economically possible in spite of the benefits cited above. However, it is certainly worth some evaluation and discussion. Included is a reference paper done by the University of Capetown in South Africa on "Mitigating the Generation of Acid Mine Drainage from Copper Sulfide tailings impoundments in perpetuity: "A Case Study for an Integrated Management Strategy" by Hesketh, Broadhurst and Harrison in 2009. This study showed successful separation of nearly 100% of the pyrite from a copper porphyry tailing.

  - *Recommended Change*: Evaluate this item in more detail in conjunction with the Pebble Limited Partnership. Make changes to the document in many places. (Doc. #4818.3, p. 32 to 33)

- *Section 4, Page 4-9*
  - *Comment:* The following comment is an example of how possible mitigation methods could reduce the level of environmental concern and significantly alter the conclusions of impact if the mine plan used in the assessment had been vetted through the environmental

and permitting review processes. The Simplified Schematic of Mined Material Processing does not separate the waste rock into PAG waste rock and NAG waste rock. This is important since the PAG waste rock can have impacts on the environment if not placed properly and if considerable acid formation occurs. The Northern Dynasty Minerals, Ltd. 2011 report states that the PAG waste rock will be piled on the west side of the pit and will be processed at the end of the mining operations and the tailings will be placed in the mine pit. If the price of copper drops, it may not be economically feasible to run this material through the mill at that time (it is low grade ore). This possibility must be addressed for long term post-closure, particularly with regard to water capture and treatment. If the material is strongly PAG, it should not be allowed to place this material in the mine pit since it will potentially affect groundwater in the area for a very long time if not treated. Also, full capture and treatment could be difficult in the long term. Table 4 of Appendix H shows that the Pebble East Pre-Tertiary waste rock humidity cell tests result is an average pH of 4.8.

  - *Recommended Change:* Revise the Schematic to include PAG and NAG waste rock. According to Northern Dynasty Minerals, Ltd., the 25 year plan would produce 2.4 billion tons of NAG and 0.6 billion tons of PAG. Include more discussion on possible impacts of leaving the PAG waste in permanent piles and in the mine pit, assuming that no future processing is undertaken. (Doc. #4818.3, p. 33)
- *Section 4.2.2, Page 4-10*
  - *Comment:* EPA points out that mill processes can affect tailings properties and reduce the acid-generating potential of tailings by producing pyrite concentrate. Cyanide processes for gold recovery are briefly described. Mitigation measures are discounted because of secondary handling requirements. (Doc. #4818.3, p. 33)
- *Section 4.3, Page 4-13*
  - *Comment:* The mine scenarios assessed by the EPA are representative of a very, large scale mining with a particular set of mine development elements that are not representative of a large percentage of porphyry copper deposit mines. For example, an open pit mine is selected while there are a number of large scale mines of such deposits that mine by bulk underground methods such as block caving, sub-level caving vertical crater retreat and other underground methods. The volume of waste rock created by such underground mining methods is several orders of magnitude less than that assumed in the EPA mine scenarios. (Doc. #4818.3, p. 35)
- *Section 4.3, Page 4-13*
  - *Comment:* The tailings disposal method by hydraulically placed, slurry tailings is one of a number of methods that can be considered. While it is the most favored of the disposal methods for cost, there is an increasing tendency to adopt alternative methods such as paste and filtered, dry stacked tailings that effectively address water management issues and environmental protection. Paste tailings technology is being applied at large scale porphyry copper mines such as the Esperanza mine in Chile. These alternative tailings disposal methods permit greater freedom for the selection of disposal facilities and can be used to address specific environmental concerns. For example, with a smaller footprint, the need to build a cross valley dam can be eliminated, along with impacts to stream flow and salmon habitat. By selecting a tailings disposal method that requires the tailings storage facility in a location where the stream impact is maximized, the Assessment results in environmental impacts greater than can be achieved by alternative methods.

(Doc. #4818.3, p. 36)

Northern Dynasty Minerals Limited (Doc. #4611.5)

- The Assessment page 4-8: Section 4.2.2 states: "Crushed ore is carried by truck or conveyer to a ball mill, where particle size is further reduced (e.g., less than 200 μm) …" and "Bulk tailings are the materials left after the first flotation circuit, and are directed to a tailings storage facility (TSF)…" and later states in the same paragraph "The copper molybdenum (+gold) concentrate may be fed through a second ball mill to grind the particles again (e.g., to less than 25 μm) …". This paragraph describes the particle size after passage though the ball mill "…less than 200 μm" (0.2 mm) and the second ball mill which reduces the particle size to "to less than 25 μm" (0.025 mm). However, on page 4-10, in Section 4.2.3, particle sizes of the tailings are stated to be "silt to fine sand (0.001- to 0.6-mm)…". On page 4-49 the Assessment states: "The bulk tailings would be uniformly graded, consist largely of sand and silt-sized particles (D80 = 200 μm)". However, the data presented in Figure 4-13 conflicts with these statements in the Assessment regarding particle size and the fact that the particles stored as tailings "would be uniformly graded". This discrepancy should be explained, since particle size is a critical, determinate factor in supporting assumptions and conclusions regarding the fate of tailings released downstream in the Failure Scenario presented in Chapter 6 of the Assessment. On page 4-49 the Assessment states that bulk tailings would make up 85% of the mass with pyritic tailings comprising 14% of the tailings with a D80 of 30 μm (0.03 mm). That means that at least 82% of the particles in the tailings would be less than 0.2 mm in diameter. Threshold shear velocity to initiate transport for particles of this size is approximately 0.04 ft/sec. According to Box 4-9 on page 4-57 all tailings particles are assumed to have a diameter of 1 mm or less. Threshold shear velocity to initiate transport for a 1 mm particle is approximately 0.08 ft/sec, which is less than half the velocity cited (0.16 ft/sec) in Box 4-9. What these differences mean is that the entire modeling effort on sediment transport is suspect in the Assessment. The consequences of incorrectly characterizing the fate of sediments released from the tailings facility during the Failure Scenario is that sediment would be transported at much lower water velocities than presented in Box 4-9. This questionable characterization and assumption is critical to the conclusions regarding the fate of sediments released and the ability of those sediments to form dam(s) in areas downstream in the main stem Koktuli, Mulchatna, or Nushagak Rivers. This entire topic in the Assessment should be reevaluated to determine if any incorrect or false assumptions have been made. (p. 16 to 17)

The Pebble Limited Partnership (Doc. #4962)

- 4.2.3 Tailings Storage: 4-1 1 A dam designed as a hybrid upstream/centerline was recently constructed at the Fort Knox Mine tailings impoundment near Fairbanks, Alaska. The downstream method is considered more stable, but it is also the most expensive option. Centerline construction is a hybrid of upstream and downstream methods and has risks and costs lying between them (Martin et al. 2002).
  THE ABOVE STATEMENT IS NOT FROM MARTIN ET AL. (2002) WHO STATES THAT "CENTERLINE AND DOWNSTREAM CONSTRUCTED TAILINGS DAMS ARE GENERALLY CONSIDERED TO BE MORE ROBUST THAN UPSTREAM TAILINGS DAMS" BUT FROM CHAMBERS AND HIGMAN (2011), WHO STATE THAT "CENTERLINE CONSTRUCTION IS A HYBRID OF DOWNSTREAM TYPE DAM CONSTRUCTION, AND FROM A SEISMIC STABILITY STANDPOINT THE

RISK IS LIES BETWEEN THAT OF CENTERLINE AND UPSTREAM TYPES". THE REFERENCE IS CORRECTLY CITED BUT INCORRECTLY QUOTED IN APPENDIX I. (p. 47)

Sheila Wehmeyer (Doc. #3486)

- The authors have an obvious lack of exposure to the mining industry in general, and to Alaska specifically. For instance, Table 4.4 includes a flow chart suggesting a ball mill process after concentrate has been created – a process which makes no sense. (p. 2)

Gregory A. Beischer (Doc. #4372.1)

- The authors have an obvious lack of exposure to the mining industry in general, and to Alaska specifically. For instance, Table 4.4 includes a flow chart suggesting a ball mill process after concentrate has been created – a process which makes no sense. (p.2, Note, reference to Table 4.4 should be Figure 4.4)
- No exposure to or design input from AK industrial developers. For instance, in section 4.2.3 (page 4-11) the author states that geomembrane technology has not been available long enough to predict service life, based on personal communications with a single geombrane supplier and a modified bitumen roofing supplier. Significant data on geomembrane service life are almost certainly available from mining and other industry and governmental sources. Geomembrane/geotextile materials have been widely used in mining for well over 30 years, and are key components of virtually all hazardous and radioactive waste landfill designs in the US. In the latter application, detailed studies are normally required to predict facility performance over the long term. (p. 4)

C. HYPOTHETICAL MINING SCENARIO

National Park Service (inclusive of USGS) (Doc. #4607)

- Overall Scope: Though the intent of the Assessment is to address a typical mine scenario, its focus is on a single large mine. While the report makes some attempt at addressing cumulative impacts of multiple large mine projects, this scenario should be developed more fully, and should include scenarios of smaller developments on other claims in the area. (p. 2)
- Maximum Mine Scenario: The maximum mine scenario outlined in the Assessment mentions the likelihood of an underground component that would use block cave mining methods, but there is nothing in the Assessment document that addresses the risks and impacts associated with block caving at the proposed Pebble site. Considering the complex hydrology of the area, the report should discuss the potential impacts of block caving to surface and groundwater resources and whether an underground mining operation would require a de-watering system similar to the one described for an open pit. It should also identify monitoring and other issues unique to the underground component that should be considered after the mine is closed. (p. 4)
- Section 4 and Appendix I: On water quality mitigation, refer to the non-acid generating versus acid-generating potential of overburden and waste rock as critical controls on mitigation practices for any proposed development. Yet this assessment does not document, present, cite or refer to any existing mineralogic or analytical geochemical data on material

properties from the actual Nushagak or Kvichak watersheds. (p. 6)

Alaska Department of Natural Resources (Doc. #4818.2 and 4818.3)

- The Assessment does not adequately consider Alaska regulations, standards, or the mitigating aspects of modern mine construction methods, operation, and closure. The Assessment provides a very basic review from dated mining projects outside of this region that do not adhere to modern mining methods, regulations, or engineering standards. These examples, which may have no applicability to this study area, were used to predict potential impacts to the study area. (Doc. #4818.2, p. 3)
- The hypothetical inflows and outflows of a speculative design do not constitute a water balance. A fundamental element in any mine review is an accurate water balance for the project. The Assessment attempts to describe the negative hydrological effects of a conceptual and unpermitted facility, but an understanding of water balance cannot be reached in the absence of a detailed proposal, including proposed water use within the facility itself. (Doc. #4818.2, p. 4)
- The Assessment does not take into account the seasonal fluctuations of groundwater and surface water flow and its effect on determining impacts from the mining scenario. Furthermore, the Assessment does not consider the substantial amount of information contained in the EBD. This includes information needed to determine the rates of groundwater flow, soils composition, porosity, hydraulic conductivities, permeability, presence of permafrost, fracturing in bedrock and other important aspects of groundwater before any mine development. (Doc. #4818.2, p. 4)
- There are hundreds of references to groundwater in the Assessment and it is repeatedly listed as a key factor in fish habitat and other wildlife habitat functions. Yet, hydrogeology within the proposed pit and tailings storage facilities is not described in the Assessment. (Doc. #4818.2, p. 5)
- The Assessment assumes that the mine would be located on a water divide and there will be little groundwater contribution into the area defined by the cone of depression. However, the surface water divide does not necessarily match the groundwater divide. The Assessment did not evaluate regional groundwater flow to determine the location of the groundwater divide. (Doc. #4818.2, p. 5)
- The amount of water used during mining operations is not consistently reported in the Assessment. This has major implications to the water balance, instream flows, and the health of fisheries below the hypothetical mine. Dewatering and mining activities in the mine site will change the local, and possibly the regional, groundwater flow field, which will change the water balance. (Doc. #4818.2, p. 5)
- The Assessment does not adequately consider the complex, site-specific and stream flow conditions and relate the information directly to measured fish/salmon presence and potential impact. The EBD contains information that shows gaining and losing reaches in the area of study. However, the Assessment does not include sufficient information on groundwater / surface water interactions that must be used to estimate impacts to fish habitat from mining activity. (Doc. #4818.2, p. 5)
- The Assessment provides examples of impacts from mines developed from the late 1800 and early 1900s, related to acid mine drainage and mobilization of metals and does not distinguish nor consider current mine technology or regulatory framework and oversight to

prevent environmental harm. These historic examples do not apply directly to a modern mine under current regulatory regimes. (Doc. #4818.2, p. 8)

- Although the document is titled An Assessment of Potential Mining Impacts on Salmon Ecosystems of Bristol Bay, Alaska, the Executive Summary limits the scope of the watershed assessment to the Nushagak and Kvichak River watersheds. However, in assessing potential impact of mining to the study area, most of the focus and discussion is limited to the area of the North Fork and South Fork Koktuli Rivers, Upper Talarik Creek and the hypothetical mine site.
    - While the presentation of the various geographic scales and associated information gives perspective to the expansive area that makes up the larger Bristol Bay region, the Assessment fails to address or quantify the potential impacts of the hypothetical mine as it relates to the various scales it presents.
    - As an example, if Bristol Bay has about 90,000 km of streams and Nushagak and Kvichak has about 58,000 km of streams, those numbers and associated contribution to the respective fish contribution should be compared with the area of streams that would be impacted by the mine to give an overall perspective of impacts. The Assessment cites that 125.1 kilometers of streams would be lost for the maximum hypothetical mine scenario which would equate to an overall stream loss of 0.1 percent of the Bristol Bay watershed or about 0.2 percent of the Nushagak and Kvichak watersheds (Furthermore, presentation of kilometers down to the tenth of a kilometer implies a level of accuracy in impact assessment that is misleading). The Assessment fails to put into context how the loss of length of streams and habitat or area of wetlands directly relates to effects on fish production and the overall effect on subsistence, sport or commercial fishing at the larger scales. Without quantifying the effect of the impacts at each scale presented, the Assessment is essentially incomplete for the purpose of a risk assessment document. (Doc. #4818.2, p. 10)
- Data are presented on potential acid rock drainage in the Assessment, a known concern for long-term impacts from sulfide ore mining. The text in Chapter 4 (pages 4-4 through 4-7) discusses the Bingham mine results from Utah, but does not refer to site-specific information from the potential Pebble site included in Appendix H. (Doc. #4818.2, p. 12)
- *Section 2.0, 4.0, and Executive Summary*
    - *Comment:* The report is lacking information on regional hydrogeology, local hydrogeology, groundwater and surface water interaction. A mine of this size could greatly impact the water balance in the area. A more detailed understanding of the above area is needed.
    - *Recommended Change*: Provide a hydrogeological analysis on the watershed. The report should include regional and local geology and hydrogeology, and surface water and groundwater interaction as well. Provide cross-section, logs, lithologies, groundwater levels, and hydrographs of the aquifers. Provide estimation of hydraulic parameters for the aquifers. (Doc. #4818.3, p. 16)
- *Section 2.0 and 4.3.7*
    - *Comment:* High seasonal fluctuations exist in the mine area as shown in Figure 2-7, page 2-23. However, the seasonal effects were not adequately considered in the water balance estimation. Frozen conditions would have a major impact on flows in creeks and runoff. Peak seasonal precipitation and snow melt would also have a major impact on the water

balance. Water balance estimated with averaged precipitation (as in Box 4-2, page 4-28) will not represent the seasonal field conditions.
    - *Recommended Change:* Provide temporal and seasonal fluctuation of rainfall, stream flow, and groundwater level. Evaluate the mining impact on water balance under long term average condition and high seasonal flow condition. (Doc. #4818.3, p. 16)
- *Section 4.3.3 and 4.3.9.1, Page 4-1, 4-19, and 4-34*
    - *Comment:* "Described mining practices and our mine scenario reflect the current practice for porphyry copper mining around the world, and represent current good, but not necessarily best, mining practices. "
    - "Based on standard mining practices, we assume that drill and blast methods would be used to excavate the rock, at a processing rate of approximately 200,000 metric tons/day for both the minimum and maximum mine sizes (Table 4-3)."
    - "Material sources for road embankment fill, road topping, and riprap would be available at regular intervals along the road route, and we assume standard practices for design, construction, and operation of the road infrastructure, including design of bridges and culverts for fish passage."
    - Why are standard but not best practices assumed in the scenario? It is reasonable to assert that practices better than current best practices will be in place for any mine development in the region given the advances in technology and engineering that are likely between now and the date of construction and actual mining. (Doc. #4818.3, p. 28)
- *Section 4, Page 4-1*
    - *Comment:* EPA uses basic concepts of engineering features in general descriptions of a broad assortment of technical issues related to tailings dams and mining. For example, tailings dams are described as being upstream, centerline, or downstream fill. Such elementary level descriptions defy technical review because of the lack of specific information. There are no conceptual designs, site investigation reports, engineering plans or specifications. EPA then describes impacts of such features in terms of their physical presence (e.g. footprint) and in terms of hypothetical, catastrophic failures. In fact, there is a probability that any engineering feature will fail, including buildings, bridges, jet engines, etc.; however, the simple probability of failure does not ensure its failure, and the benefits of those features provide incentive to take the risk that the failure does not occur because of mitigation measures engineered into the design. For example, Figure 5 in Silva, et al., 2008 shows tolerable risk based on annual probably of failure compared to people and dollars lost for various industrial features including mine pit slopes, dams, commercial aviation, and super tankers. This paper also includes an in depth review of risk management at an actual operating mine with tailings dams. (Doc. #4818.3, p. 28 to 29)
- *Chapter 4*
    - *Comment:* EPA mine scenarios consider minimum and maximum sized mines. In terms of mined ore/tailings disposal volumes those boundaries are 2 billion metric tons (tonnes) and 6.5 billion tonnes, respectively. At 2 billion tonnes, the minimum mine scenario would be considered a very large mine on a global scale, and exaggerates the respective potential impacts under normal operations and failure scenarios. There are probably less than 10 mines in the world with estimates of 2 billion tonnes or more of tailings. The Andina Mine in Chile is the only mine known to be studying the concept of storing 5.8

billion tonnes of tailings. There are currently no metal mines with tailings storage facilities of this magnitude. (Doc. #4818.3, p. 29)

  - *Comment:* EPA mentions the Pebble Limited Partnership (PLP) and states, "Although the Pebble deposit is used as an example of mining in the region, the assessment does not predict what the PLP may eventually propose." In Section 4.3, EPA states "Although we borrow details from Ghaffari, et.al (2011), our mine scenario is not based on a specific mine permit application..." In Section 4.3.5, EPA mentions the 2006 water rights application to ADNR by Northern Dynasty, but that application, and the Initial Application Report submitted to ADNR Dam Safety and Construction Unit which included the tailings dam concepts, are not included in Chapter 9, Cited References. The Tailings Storage Facility (TSF) 1 and other features in the EPA mine scenario are virtually identical to the conceptual location of Tailings Impoundment G and other features in the Northern Dynasty application. The dam illustrated in Figure 4-8 is based on Northern Dynasty's concept for dams at Tailings Impoundment A. It is notable that the 2006 water rights application was submitted prior to the significant volume of baseline information released by the Pebble proponents in 2011. The Assessment relies heavily on concepts developed by Northern Dynasty who are party to the Pebble Limited Partnership but do not necessary represent PLP, the prospective Pebble proponent. (Doc. #4818.3, p. 29 to 30)
  - It is difficult to make technical observations regarding the mine development model used in the Assessment because the basis of the model is comprised of a number of assumptions and not real data. While the proposed mine and scenarios that were assumed by the EPA may appear to be realistic in a sense, based on a given set of conditions, they by no means represent the only options and outcomes that could apply to a mine located in the Bristol Bay area, or any mine that is in the planning, development, operational or closure stages. (p. 30)
- *Section 4.2, Page 4-5*
  - *Comment:* EPA states that the Bristol Bay watershed encompasses 23,539 square miles, and loosely describes existing infrastructure in the region. EPA fails to compare the area of the mine scenarios as a percentage of the total area. Based on the surface areas for the minimum and maximum mine scenarios listed in Table 4-3 (and assuming the total transportation corridor is 0.25 kilometers wide), the areas of development are approximately 0.1% and 0.2% of the total area of the watershed, respectively. Note that the minimum mine size would be a very large mine on a global scale. (Doc. #4818.3, p. 31)
- *Section 4, Page 4-11 and 4-12*
  - *Comment:* The following comment is an example of how possible mitigation methods could reduce the level of environmental concern and significantly alter the conclusions of impact if the mine plan used in the assessment had been vetted through the environmental and permitting review processes.
    The illustration and narrative on these pages is identical to the narrative in the Northern Dynasty Minerals, Ltd. report with regard to the type of dam construction (i.e., initial dam will be the downstream type which is the most stable, which will be approximately 50% of the total dam height). The upper 50% will be centerline construction. Given the magnitude of this dam and the potential for serious earthquakes, this design must be evaluated in minute detail for stability. The long term strength parameters of the tailings

behind the dam must be evaluated since this could affect the stability of the upstream portion of the dam, in particular, the upper portion.

- *Recommended Change:* Use a seasoned dam expert with experience in extremely cold conditions and high risk of earthquake to provide a full evaluation of the dam design with respect to slope stability. (Doc. #4818.3, p. 34)

- *Section 4, Page 4-11 and 4-21*
  - *Comment:* The following comment is an example of how possible mitigation methods could reduce the level of environmental concern and significantly alter the conclusions of impact if the mine plan used in the assessment had been vetted through the environmental and permitting review processes. The narrative on Page 4-11 discusses some general dam design criteria and page 4-21 has a very brief discussion about the lining of the dam. The Northern Dynasty Minerals, Ltd. Report of 2011 has a detailed cross section in Figure 18.3.1 on Page 355. This design shows a 100 mil HPDE liner over a geosynthetic clay liner, surrounded by some fine material above and below to protect the liner. The Northern Dynasty Minerals, Ltd. report also states that the lack of fine material has required the use of these linings. In other words, the rest of the dam will be built out of waste rock from the mine that may be permeable. For most situations, this design would be perfectly suitable, however, given the possibility of earthquakes, the sheer volume of the tailings and the sensitivity of the fisheries downstream, the risk is very high and additional layers of protection on the dams should be evaluated, such as a secondary HDPE liner with a second GCL layer.
  - *Recommended Change:* Use a dam expert with experience in extremely cold conditions and high risk of earthquake to provide a full evaluation of the dam design and lining requirements. (Doc. #4818.3, p. 34)
- *Section 4.2.3, Page 4-11*
  - *Comment:* EPA states, "…geomembrane technology has not been available long enough to know their service life…" and generally discounts the potential mitigation value of the product. In fact, the advent of geomembranes began in 1839 when Charles Goodyear vulcanized natural rubber with sulfur which led to the development of thermoset polymers. Polyvinyl chloride resin production began in 1939 and mass production of polyethylene compounds began in 1943. The U. S. Bureau of Reclamation began using geomembranes in the 1960s. The geosynthetics industry broadly shifted to thermoplastic polymers in the 1980s. HDPE and other formulations of polyethylene are routinely approved by EPA and other international regulatory agencies for use in solid and hazardous waste landfills around the world (which have indefinite design lives, also). (Reference: Designing with Geosynthetics, 5th Edition. Koerner, 2005 ISBN-10: 0131454153) (Doc. #4818.3, p. 35)
  - *Comment:* The EPA states, "…geomembranes are generally estimated by manufacturers to last 20 to 30 years when covered by tailings (North pers. comm.) [sic]". The statement appears to be referenced based on personal communication. While this may be the approximate service life of some geomembranes exposed to ultraviolet rays (sun), it is more typical of product warranties issued by manufacturers. The lifetime of buried geomembranes has been estimated as much as 400 years or more for a high density polyethylene (HDPE) by noted experts such as Robert M. Koerner.(see citation in comment above). (Doc. #4818.3, p. 35)
- *Section 4.3, Page 4-17*

- *Comment:* The report in the first paragraph on this page states "Our mine scenario represents current good, but not necessarily best, mining practices". This is stated differently in the Executive Summary Pages ES-14 where the report states "No failure, or routine operation, is a mode of operation defined as using the highest design standards and day-to-day practices, with all equipment and management systems operated in accordance with applicable specifications and requirements practices.
    - *Recommended Change:* Reconcile the statements. (Doc. #4818.3, p. 37)
- *Chapter 4*
    - *Comment:* Much of what the Pebble Limited Partnership can do for environmental protection is based on the economics for the mine. This is not discussed in the Bristol Bay Watershed Assessment. It would be helpful to know the long term economics of the mine, which are described in detail in the Northern Dynasty Minerals, Ltd. Report of 2011, and whether they are based on conservative metal prices. The following list shows prices used in the economics calculated for the Northern Dynasty Minerals, Ltd. Report of 2011 compared to current prices.
        - Copper $2.50/lb Current $3.33/lb
        - Gold $1050/ounce Current $1610/ounce
        - Molybdenum $13.50/lb Current $14.90/lb
        - Silver $15.00/ounce Current $28.00/ounce
        - Rhenium $3000/lb Current $2900/lb
        - Palladium $490/ounce Current $618/ounce (Doc. #4818.3, p. 44)

<u>Billy Maines, Curyung Tribal Council (Doc. #4821.1)</u>

- Secondly, when looking at the operations of your mining scenario(s), it would be helpful to include seasonal differences, such as dewatering and fugitive dust. There would be drastic differences in water tables in the summer/fall versus winter/spring as well as fugitive dust from the pit.
- The document falls short on the seismic/volcanic conditions of the region. The area in question has been and will continue to be prone to seismic and volcanic activity. Company core samples have shown the active plate. What happens when this plate is open, where does the pressure go (the pressure of the ground holding down the activity of the plate) what happens to it?

<u>Tribal Councils of Nondalton et al. (Doc. #4115.2)</u>

- The assessment discusses fugitive dust only as it relates to roads. However, fugitive dust from mining operations can be a source of sulfuric acid mine drainage. A Pebble mine could have tens of thousands of explosions per year in an open pit, so the dust issue seems significant. It appears on the flow chart for impacts related to mining operations (Figure 3-2B), but it is not addressed in the text. If the matter is addressed, EPA should address it in the context of certainty versus uncertainty regarding both operations and effects. Finally, to a lay person like me, dust suppression may be feasible with respect to dust from roads, but dust suppression seems infeasible with respect to blasting in an open pit. So I think EPA needs to add text to address dust from blasting in an open pit. (p. 4)

Bristol Bay Native Corporation (Doc. #4145 and 5449.1)

- The BBWA does not adequately address the difficulty (risks) of actually implementing a mine design that could practicably collect and treat mining wastewater to meet water quality standards at the point of discharge, particularly the quantities of water that will be necessary for a largescale hardrock mine to operate in the "no failure" mode within the Bristol Bay watershed. If such a design is not practicable for the short-term or long-term treatment of water, EPA's "nofailure" scenario is rendered meaningless. Accordingly, EPA should at least offer examples of large-scale hardrock mining operations that have successfully treated and discharged similar volumes of wastewater. (Doc. #4145, p. 1)
- In addition to summarizing information about mineral deposits in the Nushagak and Kvichak River watersheds, this chapter provides estimates of the surface area that would be covered by a 25-year mine at the Pebble Deposit, including the mine pit, waste rock disposal areas, and a tailings storage facility (TSF1) in an unnamed drainage that is tributary to the North Fork Koktuli River. These hypothetical footprints are taken directly from Wardrop (2011). EPA estimates the mine pit to cover 1,358 acres, adjacent waste rock disposal areas to cover approximately 3,286 acres, and TSF1 to have a surface area of approximately 3,686 acres,4 or a total footprint of 8,330 acres. Whereas it is safe to assume that all habitat (wetland, aquatic, and upland) would be destroyed within this footprint, these estimates appear to be substantially low. (Doc. #4145, p. 2 to 3)
- EPA relies on engineering drawings of these mining features as shown in Wardrop (2011); Huffman-Broadway, Inc. made GIS measurements of these features that suggest the actual impacts may be substantially greater (approximately 9,400 acres), particularly if the strip of land between the mine pit and the surrounding waste rock disposal area is included, as well as a seepage cut-off area that abuts the waste rock disposal area. Inasmuch as EPA's estimated 25- year Pebble mine footprint appears to be more than 1,000 acres too low, its estimates of direct losses of habitat will also be correspondingly low. (Doc. #4145, p. 3)
- The EPA should describe any mine, preferably a copper-porphyry mine, that is currently able to treat waste streams of the magnitude described in the water balance (Table 4-5, p. 4-30) to meet low hardness-based metals criteria end-of-pipe (i.e., no dilution). Every major mine in Alaska currently operates with some sort of mixing zone to provide much needed dilution in order to comply with the applicable State of Alaska Water Quality Criteria (WQC). Yet the wastewater streams at these other Alaska mines are a mere fraction of what would be expected for a project of Pebble's magnitude (see Table 1, Riley and Yocom, 2011). Moreover, the water balance significantly underestimates the volume of contaminated water that would require treatment during operation and post-closure. (Doc. #5449.1, p. 1)
- It is somewhat alarming to find in such a professionally crafted and scientifically-based document no reference whatsoever for mean net annual precipitation, the hydrologic "driver" for all site water management and starting point for a credible water balance. The EPA "estimated" a mean net annual precipitation (MNAP) of 803 mm (31.61 inches/year) for the mine site and 804 mm (31.65 inches/year) for the tailings storage facilities (Box 4-2, p. 28). The Environmental Baseline Document (EBD) prepared by the Pebble Limited Partnership (PLP, 2012) calculated MNAP for all 15 sub-basins within the watershed in order to reconcile observed stream flows and runoff with precipitation data collected at several met stations in the project area.2 The authors of the EBD assume that precipitation data was under-represented due to wind interference with the gages. MNAP for the TSF 1 site was calculated to be 45.7 inches/year, nearly 50% higher than the 31.65 inches/year estimated by

EPA in the DBBWA. When considering the minimum 4,000 acre (TSF 1) to the maximum 12,000 acre (TSF 1,2 and 3) footprint for the higher elevation tailings storage facilities, this difference in MNAP indicates that the water balance as shown in Table 4-5 significantly underestimates the minimum and maximum wastewater treatment requirements. (Doc. #5449.1, p. 1 to 2)

- Water treatment systems, including collection and conveyance structures, also need to be designed to handle anticipated peak flows. Accordingly, the water balance should be bracketed in terms of anticipated extreme wet years and extreme dry years. This is critical because water treatment systems, as well as the collection and conveyance systems that would deliver contaminated site water for treatment, must be adequately sized to accommodate these extreme flows. And the Final BBWA should address the feasibility, based on operating mines elsewhere and state-of-the-art wastewater treatment technologies, of properly collecting, conveying and treating wastewater streams of the magnitude depicted in the water balance to meet end-of-pipe low hardness-based metals WQC without relying on dilution. (Doc. #5449.1, p. 2)
- During operation, per Table 4-5, the tailings are expected to consume 95% of all site water consumed, or approximately 35% of all site water captured. This seems high, as does the 46% pore space by volume within the consolidated tailings. Is there a reference available? Regardless, this pore volume will migrate over time into the colluvium and fractured bedrock underlying the tailings. The "no failure" scenario anticipates that seepage of tailings leachate will simply be captured in wells downstream of the tailings dam, sent to a treatment facility and discharged to a nearby stream. The assessment does not consider the site-specific and uncommonly porous nature of the surficial deposits and fractured bedrock in the project area, which helps explain the high connectivity between surface water and groundwater that plays an important role in sustaining high quality salmon habitat. Capturing leachate in each TSF without a fully lined impoundment, as envisioned in the no failure scenario, ignores the hydraulic conductivity data from site TSF 1 (e.g., piezometer GH08-170) and other information presented in the PLP EBD documents which place in serious doubt the ability of a conventional, unlined tailings impoundment to capture toxic tailings leachate before it enters the local groundwater system. (Doc. #5449.1, p. 2 to 3)
- Lastly, the post-closure water balance shows over half the site water being "consumed" in the mine pit. This may be true while the pit is filling but once filled, all site water will be "reintroduced." It is also highly conceivable that the mine pit would be filled at an accelerated schedule to reduce oxidation of mineralized sections of the pit wall (as was proposed for the Crown Jewel project in Washington State), thus advancing the time when all site water (well over 76.3 million cubic meters per year or 55 million gallons per day or MGD) would require capture and treatment prior to discharge to nearby streams. Are there any examples anywhere of a closed mine that treats such volumes of water and discharges treated effluent that meets applicable WQC end-of-pipe, with no dilution? (Doc. #5449.1, p. 3)
- Another significant finding that affects the feasibility of treating mine site wastewater discharges is the fact that the average mean annual temperature at the project site is below freezing for seven out of twelve months of the year (Meteorology and Climate, PLP, 2012). This means that all project site wastewater would need to be treated and discharged during a brief five month window, like the Red Dog project. But unlike Red Dog, no dilution would be available due to the preponderance of salmon spawning and rearing habitat in all nearby

receiving waters. Even if one accepts 76.3 million cubic meters as the ultimate water balance output, this annual volume of wastewater when treated and discharged over a five month period would be equal to 132 MGD, an unprecedented quantity of mine site wastewater that would need to be treated and discharged to meet very low hardness-based metals WQC end-of-pipe. (Doc. #5449.1, p. 3)

- The draft BBWA mining scenario projects up to 43.7 km2 (11,803 acres or 18.4 square miles) of tailings impoundments and 22.6 km2 (6104 acres or 9.5 square miles) of waste rock piles (Table 4-3; see also comments regarding discrepancies in area calculations). That equates to a total of approximately 66.3 km2 (17,908 acres or 28 square miles) of land, much of it if not most formerly aquatic habitat, that would need to be reclaimed. As much of the mine waste materials would be potentially acid generating, including pyritic tailings and PAG waste rock, these areas would need to be kept saturated to inhibit further oxidation and subsequent acid generation. In other words, aquatic habitat would need to be recreated on an unprecedented scale. The materials required for a reclamation effort of this magnitude would include cover material to physically isolate tailings and topsoil to enable establishment of a vegetative cover. Waters within the reclaimed areas would need to meet WQC. Accordingly, the BBWA should address the following questions:
    - Is there adequate cover material available to effectively isolate 28 square miles of potentially toxic mine waste?
    - Could top soils removed during mining operations, which would include a significant quantity of peat, be stockpiled for decades and still be viable as a growth medium?
    - Has any mining project in a sub-arctic region ever successfully achieved reclamation of this nature on so large a scale?

  A similar question regarding the availability of material suitable for constructing fully lined tailings impoundments should also be addressed as the tailings and PAG waste rock do not appear to be acceptable as clean fill material and are not likely to be suitable for unconfined disposal in waters of the U.S. (see Riley and Yocom, 2011 for further discussion). (Doc. #5449.1, p. 3 to 4)

<u>The Pebble Limited Partnership (Doc. #3797.2)</u>

- The Need to Adequately Describe and Assess Mine Mitigation Measures, Using "Best Practices." The peer reviewers should be asked whether the report adequately assesses specific available design, pollution control, and mitigation technologies, including (but not limited to) containment or impoundment structures; water treatment, retention, and release options; milling of potentially acid generating (PAG) tailings or waste rock; mitigation and monitoring; adaptive measures in the event of failures; and habitat modification. EPA's Assessment (at p. 4-1) states that the described mining practices "represent current good, but not necessarily best, mining practices." The peer reviewers should be asked whether "best mining practices" should be described and how the use of best available practices can limit impacts. (p. 3)

<u>Northwest Mining Association (Doc. #4119.2)</u>

- No large scale modern mine (within the past 25 years) has been approved exactly as proposed by the company. Each of the many State and federal agencies review the permit application, baseline data and EIS requirements and each requires large or minor changes before it is satisfied that the mine will be able to operate according to that agency's requirements. The Assessment assumes designs for various aspects of the mine and then criticizes those designs as not being acceptable. The Assessment does not effectively address avoidance, minimization and mitigation, all of which are employed by the agencies and the companies to address concerns that arise over the initial design. This approach to "assume design and then say it is not acceptable" was used in the Assessment for: siting of mine facilities, siting of roads, siting of tailings pipeline, design of bridges, tailings management, water use, water discharge, financial assurance (bonding), etc. (p. 6)

Northern Dynasty Minerals (Doc. #4611, 4611.5, 4611.6, 4611.7 and 4611.8)

- One of NDM's primary concerns about the Draft Assessment is that EPA presumes to measure environmental impacts of proposed mining activity without having any definitive mining proposal from PLP. The Draft Assessment makes clear that it has made a whole range of assumptions concerning fundamental details of mine activity that PLP has yet to propose, including the location of mine facilities and related infrastructure; the scale of the mine and the time period over which mining will occur; mining and milling methods; annual production; size, placement and chemistry of waste rock; and the size, placement, chemistry of tailing storage facilities, construction and mine operation practices, design criteria, mitigation measures, and a host of other assumptions. See Draft Assessment at pp. 4-13 to 4-17. With EPA's reliance on this hypothetical mining operation to prepare the Draft Assessment, it cannot pretend to have conducted a sound science-based review of the impact of PLP's proposed mine on the Bristol Bay watershed.] It would be impossible to do so given that it does not have an actual mine plan to assess. This single fact vitiates the scientific validity of the Draft Assessment and compels EPA to withhold analysis and judgment on impacts of mining activity on the subject watershed until such time as PLP actually submits definitive mine plans for consideration. (Doc. #4611, p. 4-5)
- NDM believes that EPA's proposed mining plan will differ significantly and in important ways from a plan that PLP would seek to have permitted. Without having an actual mine plan before it, EPA is left guessing as to what PLP's operation would look like. A realistic assessment of impacts from mining activity cannot be left to supposition and guesswork. Moreover, the Pebble mine would be located in an area of Alaska state land that was designated through two democratic land use planning processes for mineral exploration and development, giving further credence to the fact that EPA should wait to assess a specific mining proposal for this area rather than to base its analysis on a hypothetical mine proposal to determine whether mining is in fact an acceptable use of the area. (Doc. #4611, p. 5)
- Even if the footprint of PLP's proposed activity is similar to the 25-year hypothetical mining plan that EPA has proposed, NDM believes significant differences would remain concerning the detailed design, construction, and operation of engineered facilities, (e.g. tailings embankments) and mitigation measures proposed. Given these differences, the validity and relevance of EPA's hypothetical mining plan and the resulting environmental impacts are highly suspect. (Doc. #4611, p. 6)
- EPA's hypothetical scenario does not adequately incorporate modern engineering design features that would avoid or mitigate many of the impacts described in its report, as evidenced by the preponderance of real life examples in North America. Indeed, EPA admits that its analysis considers "good, but not necessarily best, mining practices." (p. 6)
- Failing to include in its assessment state-of-the-art measures that would avoid and mitigate many of the impacts described in the report leads to misleading, inaccurate and unfair

conclusions about the actual impacts of mining activity in the area. Indeed, Alaska agencies and EPA/other federal agencies would not permit such a plan as hypothesized by EPA in the first instance, especially with the exclusion of modern engineering design and mitigation measures. (Doc. #4611, p. 6)

- The EPA's problem formulation presents an unrealistic overestimation of potential impacts without adequate consideration of mitigation. (Doc. #4611, p.6)
- The "routine scenario" (i.e. everything working as intended including standard mitigation practices) analyzed in EPA's report shows an impact of about 100 km of lost "potentially anadromous fish spawning and rearing habitat" in the mine footprint and waste rock piles areas. Even assuming this estimate of habitat loss is correct (and it is not, as evidenced by detailed comments below), a project would never be permitted that did not mitigate for the loss of an equivalent (usually a multiple of the actual loss) amount of similar habitat either being created, or preserved. Thus, there would be a net gain in productive fish habitat and greater contribution to the fisheries. (Doc. #4611, p. 7)
- The routine scenario also assumes that only water that is surplus to mining operations would be available to release to surface waters downstream of the mine footprint area. The projected impacts are a decrease in winter water temperature, an increase in summer water temperature, and a loss of the quantity and quality of fish habitat downstream of the mine footprint. These impacts would not be allowed to occur unless appropriate mitigation was implemented. Mitigation could include: creating a storage reservoir to provide additional surface flow so that the impacts to downstream flows were lessened or eliminated; putting the water from the water treatment plant into groundwater as a surcharge and reducing water temperatures to natural conditions and supplementing surface water flows by maintaining groundwater inflow to the main channel; or installing wells to supplement surface flows in order to eliminate or lessen the downstream flow impacts. Moreover, removing natural barriers to un-utilized fish habitat (like beaver dams/rock falls, etc.) opens up significant amounts of habitat and related fish production. All of these measures are easily implemented, but EPA chose not to even consider any of this "mitigation" measures and did not include them in the Draft Assessment. (Doc. #4611, p. 7-8)
- Along the transportation corridor, under the routine scenario, EPA assumes that culverts will be improperly installed and that blockages to fish passage will occur due to improper construction and maintenance. This is not only impossible, it violates EPA's own assumption that things are working as designed. Also, EPA assumes that daily maintenance inspections will occur. NDM cannot understand how the predicted impacts could occur if everything is working according to plan. Agencies would never permit a project that had the culverts installed incorrectly and were routinely blocking fish passage. Thus, EPA's assumptions are not valid and the conditions they describe would never be permitted by either state or federal agencies. (Doc. #4611, p. 8)
- Evidence from other hard rock mining sites in Alaska is also important in a comparative analysis, but has been entirely overlooked in the Draft Assessment. Environmental performance records for all of Alaska's existing hard rock are exemplary. (Doc. #4611, p. 12)
- NDM and PLP are acutely aware of the President's Council on Environmental Quality (CEQ) Guidelines as they relate to project development and mitigation, and have been from the earliest efforts to produce a viable project design that could be permitted. NDM and PLP have also been acutely aware of the requirements of the Clean Water Act (CWA) and all that it implies when it comes to environmentally responsible project development. EPA, on the

other hand, has ignored the clear mandates of the CWA and the CEQ Guidelines in the production of its Watershed Analysis, both in the "no-failure scenario" and in the "failure scenarios". This stark contrast in the basic assumptions surrounding project concepts, PLP on one hand and EPA on the other, is disturbing. (Doc. #4611, p. 17)

- NDM and subsequently PLP have taken great pains over eight years to avoid as many environmental impacts of viable project development as possible. The project footprint has been adjusted many times and the sequencing of development of various project elements has been revised over and over to avoid and/or minimize impacts to local streams and wetlands. At no time did EPA demonstrate that it took account of any of these environmentally important design principles when coming up with its hypothetical mine concept. Further, PLP has taken great pains to design a transportation corridor that would avoid and/or minimize impacts to streams and wetlands, including incorporation of advanced approaches to stream crossings that would assure that bridges would be used wherever appropriate and that culvert design and placement would preclude failure either of the structures themselves or their abilities to provide unimpeded fish passage for all relevant species and life stages. Not only did EPA fail to incorporate appropriate road and pipeline design standards, but they assumed a failure rate that would never occur for any modern, well-designed, all-weather industrial road in Alaska, especially given today's stringent permitting requirements. PLP has always incorporated the *best* design and operational standards for physical project elements, such as tailings storage facility embankments, water treatment facilities (such as redundant, modular design) and site water collection and distribution systems. EPA's design and performance standards, as explicitly stated in their analysis were merely "good" as opposed to best; it seems this was necessary so that EPA could posit a series of still-unreasonable failures and by doing so, have something to analyze. (Doc. #4611, p. 18)
- Another glaring lapse is EPA's failure to acknowledge and incorporate one of the most basic requirements of the permitting process: full, functional mitigation for all unavoidable, residual project impacts. PLP has consistently acknowledged its mitigation responsibility and has assumed that permit requirements would stipulate mitigation obligations amounting to a significant multiple of actual impacts, resulting in a net gain in anadromous and resident fish productive capacity (hence potential net gains to subsistence, commercial and recreational fisheries), as has been the case with other projects in Alaska. PLP has identified numerous opportunities for increasing anadromous fish habitat, as well as the productive capacity of that habitat for anadromous fish, greatly in excess of reasonably anticipated losses. Examples of such available opportunities include judicious water management, including storage, and strategic delivery of excess water to streams and aquifers without adverse impacts such as seasonally incompatible temperatures; providing access to existing but inaccessible aquatic habitats and creation of extensive new habitats such as groundwater-fed secondary channels for anadromous and resident fish spawning, rearing and overwintering in local floodplains; concentrating mitigation efforts in more heavily utilized lower portions of local watersheds (North Fork Koktuli, South Fork Koktuli, Upper Talarik Creek) in order to maximize actual use of new habitat by the fish for which it is intended. Offsite but in-watershed (Kvichak/Nushagak) opportunities include such things as fish passage at significant anadromous fish barriers, opening up very large areas to anadromous access, significantly increasing salmon runs in associated systems. More remote opportunities include facilitation of reclamation and rehabilitation activities in existing disturbed areas. EPA chose not to include any such mitigation approaches in any of its scenarios, but rather to assume the

persistence of unavoided and unmitigated adverse project impacts. This failure flies in the face of the CEQ Guidelines, requirements of the CWA, the large mine permitting process in place and familiar to all in Alaska, and is inconsistent with modern mining industry practices. (Doc. #4611, p. 18-19)

- The following tables can be found on Doc. #4611, p. 23 to 25:

Draft Watershed Reference	Commentary
Pg. 4-11: "A clay liner may have a saturated hydraulic conductivity of 10^{-8} m/s, whereas a geomembrane may have a hydraulic conductivity of approximately 10^{-10} m/s (Commonwealth of Australia 2007). However, geomembrane technology has not been available long enough to know their service life, and geomembranes are generally estimated by manufacturers to last 20 to 30 years when covered by tailings (North pers. comm.). "	• Modern clay liners are most commonly constructed with a saturated hydraulic conductivity of 10^{-9} m/s, one order of magnitude lower than the Draft Assessment suggests. • Geomembranes used in typical lining applications typically have hydraulic conductivities of 10^{-14} or 10^{-15} m/s, several orders of magnitude lower than stated. • Most of the research on geomembranes is performed by independent universities and research institutions such as the Geosynthetic Institute (http://www.geosynthetic-institute.org/).
Pg. 4-15, Table 4-3: TSF 1 surface area is 14.9 km^2.	This is inconsistent with **pg. 4-50:** "Under the partial volume dam failure, the peak flood is estimated at 1,862 m^3/s immediately downstream of the TSF 1 dam, where the contributing watershed area is only 1.4 km^2." Such a massive over-estimation by EPA eliminates credibility.
Pg. 4-20, Figure 4-7: The figure displays minimum and maximum mine footprints hypothesized and shows hypothetical mine infrastructure overlaying a map that hypothetically depicts "freshwater habitat".	Figure 4-7 fails to define freshwater habitat. The maps presented greatly exaggerate the amount of fish bearing waters and leaves the reader with the impression that there are a large number of lakes in the area. This is incorrect. What the maps should depict is the stream channels which contain or contribute water to fish bearing channels. The scale on the map only makes the exaggeration worse. NDM's analysis shows that certain maps included in the Draft Assessment exaggerate stream widths by as much as 7,000%. The situation is particularly bad in the Upper Talarik Creek watershed. The background maps should be revised to accurately depict the stream distribution in the area represented, as related to the three fish species which are the subject of the Assessment.

Draft Watershed Reference	Commentary
Pg. 4-25, Figure 4-9B: The figure, "Post Closure with No Water Management" shows a scenario after completion of mineral extraction where leachate is being generated from the tailings and waste rock piles, but no water management is occurring.	This is an inaccurate depiction of the post-closure period. The post-closure implementation period will include long term water management that effectively manages and controls any leachate that does not meet water quality criteria.
Regarding hydraulic conductivity in water balance (Box 4-2), **Pg. 4-28:** "We based our analysis on the hydraulic conductivity (k) varying with depth, with log k varying linearly from the surface to a depth of 200 m; specifically, with $k = 1 \times 10^{-4}$ m/s at the surface and $k = 1 \times 10^{-8}$ m/s at depths greater than or equal to 200 m."	This is inconsistent with **Chapter 8 of PLP's Environmental Baseline Document** **Pg. 8-25:** "The hydraulic conductivity tests in overburden … had a geometric mean of 2×10^{-5} m/s, and a median of 3×10^{-5} m/s." **Pg. 8-25:** "Response test in bedrock in the Pebble Deposit were performed near the top of rock (shallow bedrock). … The geometric mean of the calculated values was 1×10^{-5} m/s and the median was 1×10^{-5} m/s." **Impact:** EPA has overestimated hydraulic conductivity in shallow overburden and underestimated it at depth in bedrock.
Pg. 4-33: "Because premature closure is an unanticipated event, water treatment systems would likely be insufficient to treat the excessive and persistent volume of low pH water containing high metal concentrations."	This statement is incorrect. Premature closure would be one of the events planned for, with appropriate financial assurances, as part of the permitting process. Further, NDM believes PLP would ensure that sufficient water treatment capacity exists at all times to address premature closure
Page 4-45: "Several studies have estimated the probability of tailings dam failures, resulting in the failure probabilities listed below. … 1 tailings dam failure every 2,000 mine years. … 1 tailings dam failure every 2,041 mine years. … 1 tailings dam failure every 1,754 to 714 mine years."	These probabilities are not relevant. The failure case histories used to develop the probabilities are almost exclusively based on older tailings facilities started without the benefit of modern engineering practices and regulations. In all cases, mitigation of the failure would have been possible through proper investigation, design, construction, and/or operations consistent with modern mining practices. An analysis that simply utilizes a retrospective failure rate to estimate future failures at a modern mining site significantly exaggerates the risk of a TSF failure, and therefore results in a biased assessment of future outcomes.

- Given the lack of scientific rigor, the Assessment is an inadequate basis for a permitting decision for the Pebble Project, which should be evaluated pursuant to the normal Environmental Impact Statement process under NEPA. The Assessment is based on a "mining scenario" describing a mine that today could not be legally built, and other mine structures that fail to meet modern mine construction or operation methods. It is based on culverts that fail to meet modern design criteria for fish passage. It relies on data from mines constructed in the 1800s that now could not be constructed or operated in the same way. Thus, an EPA Section 404(c) veto of the Pebble Project based on this report would be a triumph of politics over science. (Doc. #4611, p. 36)

- The Assessment mistakenly suggests that fundamental permitting requirements will not be applied to a potential development within the Bristol Bay watershed. This is a fundamentally flawed premise. It is also extraordinary that an EPA document would suggest that this is a reasonable basis for its impact assessment, because it assumes that a federal regulatory process would completely ignore modern standards for tailings dams. The Assessment does not take into account these modern design criteria. (Doc. #4611, p. 37)
- The Assessment wholly ignores standards and regulatory guidelines on the design and construction of waste rock piles. These standards are clearly laid out in state and federal regulatory schemes and should be the building blocks for the development of any hypothetical mining scenario. (Doc. #4611, p. 37)
- The Assessment indicates that the assumed mining operation would modify natural runoff and infiltration, but fails to highlight the extensive studies that are required to understand baseline conditions and to determine the changes to flow conditions during construction, operation and after mine closure. These studies are fundamental requirements for the permitting process, and are required to determine appropriate mitigation measures to ameliorate potential impacts. (Doc. #4611, p. 37)
- The pipeline failure rates used in the Assessment are based on aggregated information from several countries spanning a wide range of construction techniques and pipe sizes. It is not clear what design standards to which those pipelines were constructed. (Doc. #4611, p. 37)
- The Assessment implies that mine closure will be inadequate and that the owner will not be responsible for environmental liability. This assumption is not realistic: comprehensive analyses and adequate bonding to maintain the site in perpetuity, including monitoring, maintenance, and upgrading or replacement of treatment systems as new technologies are developed, would be necessary before any development could be permitted to proceed. (Doc. #4611, p. 37)
- In its hypothetical mine scenario, EPA relies on tailings facilities built in the late 1800s while ignoring modem engineering that would have prevented historical dam failures. EPA grossly underestimates the high standard to which a mine in the Bristol Bay watershed would have to be designed and engineered in order to obtain permits to operate in the watershed. It also underestimates the role of various federal and state regulatory agencies in the permitting process that will help ensure that a technically advanced mine would be designed and operated. (Doc. #4611, p. 38)
- EPA's statistics overstate the chances of a tailings dam failure today. ICOLD statistics referenced in the report do not support the premise that tailings dam failure is a reasonable hypothesis for a modern mine operation in the Bristol Bay watershed. The Assessment incorrectly implies that generalized statistics for worldwide tailings dam failures can be applied to individual tailings dams to suggest a high potential for failure over an extended period of time. This premise is erroneous and misleading, as it is incorrect to imply that any particular proposed or actual dam structure is more or less likely to fail based solely on extrapolation of general dam failure statistics based on dissimilar dams. (Doc. #4611 p. 38)
- The new design criteria for fish passage culverts typically produce a culvert with a much

greater flow capacity, resulting in lower failure potential. The analysis of road and culvert failure in the Assessment does not address the distinction between the two culvert types, or describe adequately the advances in design criteria for fish passage, and therefore overstates the potential for failure of project culverts on fish bearing streams. (Doc. #4611, p. 39)

- A properly formulated culvert design maintains sediment, debris, and flood flow, and aquatic organism conveyance (both upstream and downstream) similar to that of the natural stream. The Alaska Department of Transportation and Public Facilities and Alaska Department of Fish and Game have collaborated to develop a comprehensive strategy that establishes design criteria to maintain the stream function for culverts in Alaska. This cooperation resulted in a *Memorandum of Agreement for the Design, Permitting, and Construction of Culverts for Fish Passage*. The design criteria within this MOA have become not only the standard for DOT&PF projects, but also for any project managed by other public and private entities in the state. The Assessment demonstrates that its authors lack knowledge of maintenance requirements and these Alaska-specific standards to maintain stream function for culverts. (Doc. #4611, p. 39)
- The mining scenario and analysis of environmental impacts failed to consider mitigation activities that are routinely adopted in the United States for mining and similar large resource and infrastructure projects. In practice, mitigation of project effects is required by federal law to the extent that is reasonably attainable. The hypothetical mining project evaluated in the Draft Assessment not only reflects a worst-case possible scenario, it also reflects an unrealistic scenario. It analyzes a mining operation scenario that has not been permitted in the United States since late in the 19th or very early in the 20th century. The document inappropriately refers to mining impacts in the last century, relying upon information from mining activities conducted in countries with lax or non-existent environmental regulations. (Doc. #4611, p. 40)
- The input assumptions used in the hydrological modeling are incorrect. For instance, an SCS-Type IA storm was used in developing one of the models used in the assessment. Based on known data for Alaska, a different SCS Type I distribution should have been used. Applying a different distribution would change the results of the analysis and reduce some of the greatly exaggerated results. (Doc. #4611, p. 40)
- There is ample precedent for the successful design, construction, and operation of tailings impoundments around the world, including Alaska. Each site is unique and the designs are specific to site conditions. The Fort Knox tailings dam is an example of a large dam that has been constructed and continues to be operated in Alaska. This tailings dam will be raised to its ultimate height of 360 ft in 2013, and it is situated in an area where the cold winter conditions are more severe than those at the Pebble site. The dam is designed to withstand the Probable Maximum Flood as well as the peak ground acceleration of 0.63g generated by a Maximum Credible Earthquake of M7.5. (Doc. #4611, p. 45)
- The Assessment also assumes fish passage problems associated with the transportation corridor, with no consideration of the internally inconsistent assumption of blocked culverts and fish passage in the routine operations scenario versus an assumption of daily maintenance inspections and proper design and avoidance measures associated with modern mine road construction techniques in the same scenario. (Doc. #4611.5, p. 8)
- In the text of the Assessment, an assumption is made that water surplus to operations needs will be routed to the streams downstream of the infrastructure footprint, but makes no mention of supplemental water from some other source to mitigate for flow reductions or

other water management measures that would address water temperature concerns. (Doc. #4611.5, p. 8)

- Table 4-2 on page 4-14 states that under the Premature Closure scenario, “Closure of mine before planned mine lifespan is reached and without planned site management”. This assumption is not “realistic” given the five-year environmental and bonding review required by the State of Alaska. What this assumption, as presented in Table 4-2 fails to recognize is that some form of site management in case of a premature closure or stoppage in production would be performed with funding from the bonds required. This is not a realistic part of a scenario and should be revised to reflect the State’s requirements. (Doc. #4611.5, p. 22)
- Figure 4-7 on page 4-20 displays minimum and maximum mine footprints hypothesized and shows hypothetical mine infrastructure overlaying a map that hypothetically depicts “freshwater habitat”. Figure 4-7 fails to define freshwater habitat and is scientifically and professionally dishonest. The maps presented greatly exaggerate the amount of fish bearing waters and leaves the reader with the impression that there are a large number of lakes in the area. This is absolutely false. What the maps should depict is the stream channels which contain or contribute water to fish bearing channels. The scale on the map only makes the exaggeration worse. The situation is particularly bad in the Upper Talarik Creek watershed. This is an example of where the Assessment clearly misleads the public about the nature and character of the streams in the area. The background maps should be revised to accurately depict the stream distribution in the area represented, as related to the three fish species which are the subject of the Assessment. (Doc. #4611.5, p. 22)
- The Assessment page 4-31: Section 4.3.8 states: “Weathering of the waste rock and pit walls would release contaminant concentrations of potential concern such as sulfates and metals. Weathering to the point where these contaminants are present in only trace amounts (at levels approaching their pre-mining background concentrations) would likely take hundreds to thousands of years, resulting in a need for management of materials and leachate over that time.” These statements draw a major conclusion without supporting science to document the claim made that sufficient weathering would take “hundreds to thousands” of years to reduce potential contaminates to pre-mine background levels. This conclusion is totally unsupported by any references or analysis to justify the claim. The Assessment should be rewritten to include scientifically defensible documentation that the assertion regarding weathering time is valid. (Doc. #4611.5, p. 22-23)
- The Assessment page 4-31: Section 4.3.8.1 Mine Pit states: “These areas containing sulfide minerals would likely be acid-generating for as long as they remained above the water surface in the pit (if they were not sealed against oxidation), resulting in low-pH water running down the sides of the pit into the water body at the bottom.” This statement is inconsistent with the conclusion earlier in Section 4.3.8 that weathering of the “mine pit” would occur over some undocumented time frame and reduce potential contaminant levels to pre-mine concentrations. The Assessment needs to be rewritten to correct this discrepancy. The Assessment presents conflicting information on pit wall weathering, thus it is impossible to adequately assess the potential ecological impacts, since no documentation is provided in the text. It also ignores the application of effective mine closure measures to ensure no contamination impacts downstream. (Doc. #4611.5, p. 23)
- The Assessment page 4-32: Section 4.3.8.2 Tailings Storage Facilities states: “An assumption in the mining industry is that tailings continue to compact, expelling interstitial water and becoming more stable over time. However, a recent analysis of data from oil sands

tailings suggests that densification of tailings may stop after a period of time (Wells 2011). Thus, the system may require continued monitoring to ensure hydraulic and physical integrity". The conclusion reached in this section of the Assessment is not supported by a scientifically defensible argument. The Assessment fails to present any information or analysis to show that the apparent conclusion reached by Wells (2011) is applicable to the type of tailings facility envisioned in the hypothetical mine scenario, that the manner in which the tailings from the oil sands are placed into their tailings facility is similar to what would occur at the hypothetical mine site, and that the particle size distribution in the oil sands tailing facility is identical to those in the mine's hypothetical tailings facility. The reader is given no basis on which to reach the same conclusion as the Assessment. The conclusion as it now is described does not meet any reasonable definition of a scientifically valid assessment. The Assessment should be rewritten to provide evidence that the two situations are comparable in order to support the conclusion that continual monitoring will be required. (Doc. #4611.5, p. 23)

- The Assessment page 4-3: Section 4.3.8.5 Premature Closure. This entire section of the Assessment fails to address the requirements of the State of Alaska regarding five-year environmental audits and bonding review. This section as written is nothing more than uninformed, idle speculation and has no place in an ecological risk assessment. If the authors have any specific conclusions that they wish to draw regarding this component of the hypothetical mine scenario, then they should comprehensively document the conditions under which this uninformed speculation could occur. As is, this section adds nothing of scientifically defensible substance to the Assessment and should be deleted as a component of the mine development and operations scenario. (Doc. #4611.5, p. 23)
- The Assessment page 4-34: Section 4.3.9.1 Roads states: "…we assume standard practices for design, construction, and operation of the road infrastructure, including design of bridges and culverts for fish passage. Costs for the road would include daily maintenance crew and equipment; crushed road topping every 5 years; culvert, embankment, riprap, guardrail and river training structures; regular bridge and other inspections; dust suppression; snow removal; and avalanche control and removal …" The Assessment makes the various assumptions outlined in Section 4.3.9.1, but fails to mention the requirements of the Memorandum of Understanding between the Alaska Departments of Transportation and Fish and Game regarding fish passage requirements at road crossings and whether the Assessment assumes that design and maintenance requirements for a private road would be different than that described in the Assessment. The assumption of "standard practices" in design of road crossings is not specific and does not provide the reader any comparison between what the authors assumed a standard practice is and what the State of Alaska requirements might be for a large mining project. Therefore, it is impossible to determine if there is a scientifically defensible comparison between the assumptions made by the Assessment and the reality of what considerations would be included in any "realistic" road design. This issue is particularly important, since the Assessment assumes daily road maintenance and inspection, given the conclusions about the impacts of a transportation corridor on fish passage later in the Assessment. There appears to be a complete disconnect between the assumptions the Assessment presents in this section and the unsupported and inappropriately documented conclusions in the non-failure scenario of the Assessment in Chapter 5. (Doc. #4611.5, p. 24)
- The Assessment beginning on page 4-26 presents the assumptions in the mine development scenario relating to water management. Review of the Assessment's pages 4-26 to 4-30, Box

4-2, and Tables 4-3 and 4-5 raise serious concern about the conclusions reached in the Assessment regarding water management and water balance. The Assessment fails to provide an adequate explanation of or sufficient detail on how the values in Table 4-5 were derived. The water balance modeling results in the Assessment are suspect and unreliable. (Doc. #4611.5, p. 26)

- The Assessment on page 4-26, third bullet states: "Capture of precipitation falling on the mine components. Precipitation on the mine pit, waste rock piles, and TSFs would be collected and stored to use as process water, eliminating it as a source of stream recharge". The Assessment fails to provide any support or analysis of the conclusion that precipitation falling on the mine components would be used exclusively as process water and that some portion, after treatment, could not be used to replace some of the stream flow reductions downstream of the mine footprint. (Doc. #4611.5, p. 26)
- The Assessment, page 4-26 Table 4-5 Water Balance Estimates for the Mine Scenario. Table 4-5 appears to present data that is inconsistent with logic and reason. How can facilities that have a total volume of 229% of another have only 4% more pore water volume? Table 4-5 contains a gross error in its water balance calculations and calls into question the accuracy of the modeling and the competence of the modelers, authors and EPA reviewers of the Assessment. (Doc. #4611.5, p. 26)
- The Assessment, page 4-26 Table 4-5 Water Balance Estimates for the Mine Scenario. Table 4-5, under the Start-Up scenario (which is defined in the Assessment as the first few years of operations) shows a pore water volume in TSF 1 as 25,500,000 m3 which is the same pore water volume as the minimum mine size reported after 25 years of operations. How can this be? The pore water volume from the start-up period and the 25-yr. mine life cannot be the same. The modeling is in error. The Assessment reviewers did not carefully review this table and it is these kinds of ridiculous errors that cast doubt on the modeling results in the Assessment and whether or not they can be trusted and or should be ignored. (Doc. #4611.5, p. 26)
- The Assessment on page 8-2, 8.1.1 Routine Operations, 4. Indirect effects of stream and wetland removal; states: "These indirect effects cannot be quantified, but it is likely that one or more of these mechanisms would diminish fish production downstream of the mine in each watershed." Given the earlier comments regarding the Assessment's lack of scientifically defensible analysis to support any of the conclusions reached in this section of the Assessment, that EPA failed to present a routine operations scenario that even meets current policy and regulations with respect to mitigation requirements for this type of project, and that EPA failed to consider even the most elementary mitigation strategies to address the ridiculous hypothetical impacts of mine development clearly demonstrates that the Assessment is not based on the policy and principles in EPA's ecological risk assessment guidelines and information quality guidelines. (Doc. #4611.5, p. 49)
- The "Mine Scenario" narrows the focus of the assessment inappropriately. The assessment is supposed to be on the effects of mining generally, not on the Pebble Mine alone. Pebble is one of five planning units in the Nushagak and Kvichak drainages specifically set aside in the Bristol Bay Area Plan (2005) for mineral exploration and mining because they have significant resources, either measured or inferred, that may experience minerals exploration or development during the planning period. In addition, there are several existing, developed mines and other mineralized areas and claims identified in the Plan that are not set aside but are ripe for development; some are considerably larger in land area than Pebble and others,

though economically viable, are considerably smaller. These other mines and prospects contain a variety of ore types and target minerals, and would have a range of potential development approaches and impacts extending well beyond those reasonably anticipated for the Pebble prospect. (Doc. #4611.6, p. 5)

- 4-17 §3 This paragraph parrots a common but erroneous assertion that the Pebble deposit is located "in the headwaters of the Nushagak River and Kvichak River watersheds." This is incorrect. The Pebble deposit is located in the headwaters of two modest-sized tributaries of the Nushagak system and the Kvichak system. The headwaters of the 225-mi-long Kvichak system is the source of the Tlikakila River at Lake Clark Pass. This is in the Chigmit Mountain Range, which separates Southwest Alaska from Cook Inlet, approximately 137 watercourse mi upstream of the mouth of Upper Talarik Creek, or 109 mi as the crow flies ENE from the Pebble site. The headwaters of the 315-mi-long Nushagak system is not the upper (named) Nushagak River, but the source of the Mulchatna River above Turquoise Lake. This is approximately 168 watercourse mi upstream of the mouth of the Koktuli River, which is 35 mi downstream of the confluence of the north and south forks of this stream, or 79 mi as the crow flies NE from the Pebble site. This headwater location is also in the Chigmit Mountain Range. Very roughly, there are about a dozenand- a-half drainages as large as or larger than Upper Talarik Creek tributary to the main rivers (Kvichak, Newhalen) and lakes (Iliamna Lake and Lake Clark) in the Kvichak system. This does not count Iliamna Lake or Lake Clark themselves. Again very roughly, there are about two dozen drainages tributary to the main rivers in the Nushagak system (Nushagak, Mulchatna, Nuyakuk) as large as or larger than either the North Fork or South Fork Koktuli. There are many smaller but significant drainages tributary to the main lakes and rivers in both systems. (Doc. #4611.6, p. 9)
- 4-17 §3 This paragraph repeats the misstatement that the Pebble deposit "is similar to other sites in the area where mineral exploration is proceeding (Figure 4-6). This similarity means that much of our analysis is transferable to other portions of the region." In reality, the Pebble deposit is the only copper porphyry deposit of the five mineral deposits identified the 2005 Bristol Bay Area Plan as most likely to be developed within the planning period (see comments above). (Doc. #4611.6, p. 9)
- 4-33 §4 This paragraph states, "Premature closures can range from cessation of mining with continued monitoring of the site to complete abandonment of the site. As a result, environmental conditions at a prematurely closed mine may be equivalent to those under a planned closure, may require designation as a Superfund site, or may fall anywhere between these extremes." This statement is unrealistic and incorrect. The State of Alaska has very strict rules regarding environmental and operational audits which recur on an enforced 5-year cycle. Two closure plans are required in association with each audit cycle, one for end of mine life and another for premature closure within the 7 subsequent five years, when the next environmental and operational audit is due. Furthermore, bonding requirements are re-evaluated, and sufficient bonding is required to satisfy both closure scenarios. The only reasonable premature closure scenario is "cessation of mining with continued monitoring of the site" with environmental conditions "equivalent to those under a planned closure." EPA should have known this and incorporated this firm Alaska policy fully into closure evaluation. This is a serious oversight, and casts question on the adequacy and orientation of the analysis. (Doc. #4611.6, p. 9 to 10)
- We identified several issues with the mining background and hypothetical scenarios selected

by the EPA for review. The EPA Report claims not to be based on a specific mine permit application, yet draws heavily on and specifically references the Pebble Project throughout the EPA Report. Given that the report was developed as a proposal for all of Bristol Bay, the dedication of an entire chapter to a hypothetical scenario based on the geographic location, type of minerals, and potential design of the Pebble Project is notable. The heavy use of Ghaffari et al. (2011) as a reference for the development of the hypothetical mining scenarios and for Pebble deposit-specific information further suggests that the proposed risks may be specific to the Pebble Project (referred to 26 times in Chapter 4), as it is a technical document prepared by WARDROP (a Tetra Tech Company) that details a preliminary assessment of the Pebble Project. Several statements made in the EPA Report also require corroborating references and/or studies. (Doc. #4116.7, p. 10)

- "Our mine scenario represents current good, but not necessarily best, mining practices." (pg. 4-17) The current practices in use at some porphyry copper mines are the result of years of the evolution in engineering design. Implementing current best practices at some older sites may be hampered by historic mine development decisions and may therefore be limited to mitigation or remediation efforts. The assumption on the quality of mining practices (i.e. good versus best) that may be applied at a future mine in the Bristol Bay watershed is purely speculative and biases the BBWA. Ultimately, the operational practices will have to conform to a plan approved by the oversight regulatory agencies, and will be designed to meet the unique requirements of the site. (Doc. #4611.8, p. 28)
- "At each TSF, a rockfill starter dam would be constructed, with a liner on the upstream dam face and seepage capture and toe drain systems installed at the upstream toe, and with perpendicular drains installed to direct seepage toward collection ponds." (pg. 4-21). Such collection systems are basic in their design and operation with few components subject to potential failure. Failure modes such as crushing, blockage, or blinding of the toe drainage systems are known and can be readily accounted for during design and construction. These are typical engineered solutions that have already been developed and approved by regulatory agencies to mitigate these types of failure scenarios. Such solutions appear to have been ignored in the BBWA. Conventional water treatment practices typically involve chemical addition steps to adjust the pH of the water and precipitate metals. Following the chemical addition stages, physical separation of the solids from the water is often achieved through gravity settling or filtration. These processes are mechanically simple and require some, but not extensive, operator control. Due to their simplicity, the opportunity for system breakdown is significantly reduced from the scenarios considered in the BBWA. (Doc. #4611.8, p. 30 to 31)
- "PAG waste rock would be stored separately from NAG waste rock. As noted above, waste rock could be processed if commodity prices rose to the point where it was economical to process it, or if balancing the chemistry of the flotation process made this advantageous. Alternatively, PAG waste rock might be milled at the end of mining to both exploit the mineral content of the rock and to direct acid-generating pyrite to the TSF or the pit, where it might be more easily managed. Waste rock also might be placed back in the pit (e.g., waste rock from the eastern part of the ore body might be placed in the western portion of the pit once it is fully mined)." (pg. 4-23)
  This paragraph acknowledges that the management of PAG and NAG rock during the active mining phase cannot be fully determined based on the extent of information presently available. Also, management approaches are likely to change over the active life of the mine

as new situations develop and new information becomes available. Although not acknowledged in the BBWA, water collection and treatment systems are also likely to be refined and optimized during the operation of the mine. (Doc. #4611.8, p. 32-33)

- **Biased Use of Selected Case Histories**: Two case histories are discussed in the BBWA in relation to failures of water collection and treatment systems.
    - "When a mine reopens after premature closure, the owners may change the mining plan, may not implement the same mitigation practices, or may negotiate new effluent permits. For example, the Gibraltar copper mine in British Columbia was permitted as a zero-discharge operation. When it closed, then reopened under new ownership, it was permitted to allow effluent discharge to the Fraser River, and this permit included a 92-m dilution zone for copper and other metals." (pg. 4-33)

  The BBWA appears to suggest the reopening of this mine under a new permit was inappropriate. Updates to the permit are appropriate based on new information and an improved understanding of the risks associated with discharge to the receiving environment. Stakeholder consultation and regulatory approval is required before any such alteration of the discharge permit could take place. This statement overlooks the process that is required to obtain approval of any changes to permit conditions, which includes careful analysis by the lead regulatory agency. (Doc. #4611.8, p. 33)
- **Precipitation** The BBWA assumes annual net precipitation of 803 mm/year, 804 mm/year, and 1,830 mm/yr at the mine site, TSFs and port respectively (Box 4-2, pg. 4-28). The net precipitation estimates are used for both the pre- and post-mine construction scenarios. This implies that evaporation is roughly constant between the two scenarios. As described in the next section, this may not be a valid assumption, raising questions on the validity of the water balance analysis. (Doc. #4611.8, p. 46)
- **Evaporation** The BBWA does not account for the reduction in evaporation due to the removal of vegetation and the duff layer that exists in the pre-mine condition. This would likely result in lower evaporation losses in the post-mine construction scenario. It is well known that cleared, compacted, paved, or otherwise denuded areas have lower interception storage and resulting lower evapotranspiration rates.

  Prior to mine construction, the site is covered with trees and vegetation as well as an organic duff layer and microtopography that intercept precipitation allowing extended exposure and opportunity for evaporation as compared to a denuded area for which precipitation percolates into the ground and is unable to evaporate. Similarly the pre-mine scenario duff layer acts as a sponge that soaks up water making it available for evaporation over a longer period of time. Finally, plants with roots reaching deep below the surface continue to access water and transpire, resulting in evaporation losses of subsurface water. Extended evaporation and evapotranspiration can lead to significant water losses.

  During active mine operations, the mine site will be denuded and the vegetation and duff layer will be gone. Precipitation incident on the site will runoff faster and be diverted into ponds for treatment and release or for storage and reuse. All the ponds will likely have exposed water surfaces providing an extended period over which evaporation can occur in these smaller areas. This could result in additional water that could be managed as part of an overall site water management system to augment reduction of water due to the other site activities.

  After mine closure, large areas of the site (TSF, waste rock piles, etc.) will be revegetated and their evapotranspiration potential will increase. The mine-pit will become a large lake subjected primarily to pan evaporation. Not accounting for these changes in evaporation leads to inaccuracies and misinterpretation of the water balance. (Doc. #4611.8, p. 47)

- **On-site water use** The BBWA includes a water balance that shows 32M m3/year of water capture and 27M m3/yr of water use, of which 25M m3/year is designated as lost because of storage in the TSF. The report does not provide a reference to support their assumption of 46% voids in the tailings material. However the assumption of a void ratio of 46% filled with unrecoverable water is within the range of reported values in literature.
  While the quantitative assessment of water lost to entrainment (i.e. unrecoverable) may be within the reported range in the literature, there will be significant variability both within the literature range, and physically over the depth of the TSF as deeper tailings become compressed and release their void water back into the overlying tailings. With the large volume (e.g. 25M m3/year) of entrained water, variability in the void ratio assumptions will have large impacts on the overall water balance. Conclusions derived from the water balance about reduction in water flow to streams downgradient of the site must consider the uncertainties in the input, and hence the two scenarios presented are likely inaccurate representations. (Doc. #4611.8, p. 47-48)
- **Ground and surface water dynamics** The BBWA is vague on quantifying the impacts of mine development and operations on groundwater and does not account for potential mitigation practices to reduce the impacts of water use at the mine on downgradient streams. The report provides a short discussion of the calculation of the cone of depression around the mine pit (Box 4-2, pg. 4-28). This cone of depression was estimated to extend to approximately 1,200 m and 1,300 m from the perimeter of the mine pit under the minimum and maximum mine scenarios. However, the report does not quantify the impacts resulting from the extent of the cone of depression and simply states that "The balance of surface water and groundwater inputs to downstream reaches would shift, potentially reducing winter fish habitat and making the streams less suitable for spawning and rearing (ES-15)." The report further states that an "unquantifiable area of riparian floodplain wetland habitat would either be lost or suffer substantial changes in hydrologic connectivity with streams".
  Further evaluation needs to be performed to quantify the impacts and to demonstrate the significance of the impacts. This would allow a discussion of the adequacy or inadequacy of the mitigation measures that could be in place at the mine site. Such options for mitigation result in changes in the ground and surface water dynamics include actively managing surface water to better mimic the pre-mine construction water balance by injecting treated waters into the ground as needed to restore groundwater levels and minimize impacts down gradient of the dewatered areas. Ground water injection could also mitigate temperature concerns in the streams from the increased discharge of treated water as well as temperature concerns raised from decreasing groundwater flow. (Doc. #4611.8, p. 48).

<u>Alaska Miners Association, Inc. (Doc. #4612.1 and 4612.2)</u>

- **Questionable validity of the document** The draft assessment contains so many inaccurate examples and scenarios that we must question the validity of the document altogether. For example, the concepts of mitigation, minimization, and impact avoidance are frequently avoided, if not ignored altogether. These techniques are key elements of any development permit in Alaska, which the report authors appear to be unaware of, or perhaps chose to overlook.

The draft assessment chooses to assume that 11 billion metric tons of ore will be mined under the not yet seen Pebble mine plan. This number, which represents the total resource and not the mineable reserve, is inflammatory and seems designed to alarm, as well as exposes the authors' unfamiliarity with mining in general.

The comparison of a hypothetical dam to structures like the Washington Monument or St. Louis Arch is unreasonable. In addition, examples of failures to said dam were modeled after case studies from mines that opened in the 1800s. It is absurd to compare the two, considering construction of a dam today would occur over 100 years later with major changes to regulatory, engineering, and environmental standards. Finally, the draft suggests that remediation may occur following a dam failure, but is uncertain. State and federal statutes require remediation in such an example to begin immediately, so designing a scenario that describes otherwise ignores mining standards and regulations in place today. (Doc. #4612.1, p. 2)

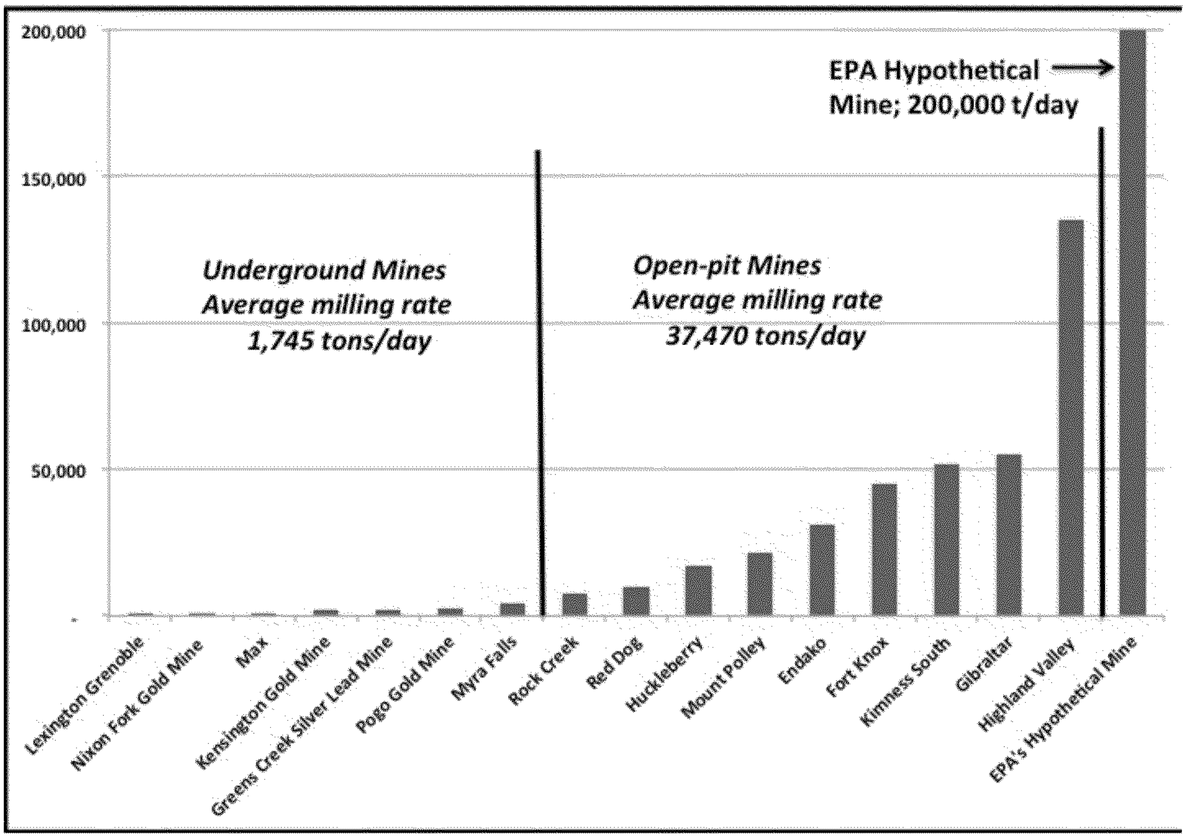
- The hypothetical mine used in the draft assessment simply would not be permitted under existing standards. Therefore, the document creates a foregone conclusion about a large-scale mine in the area and causes misconception regarding any associated scenario. The document goes as far as to suggest the mine could suddenly close while assuming no state standards such as reclamation bonding and design requirements. (Doc. #4612.1, p. 3)
- ***Review of Alaska and British Columbia Mines.*** To assess the range of likely mine sizes, this technical review researched mine sizes that currently exist in Alaska and British Columbia. Unfortunately, given the short time frame to comment on the Assessment, it was not possible to obtain surface acreage disturbed for these mines. This analysis uses milling rate as a substitute for mine surface acreage.

  Figure 1 shows the milling rate for mines in British Columbia and Alaska. (Appendix A explains the data sources for the figure). The figure shows that the Assessment's hypothetical mine is much larger than any mine in Alaska or British Columbia. In fact, the average open-pit mine in the two areas mills an average of 37,470 tons/day. EPA's hypothetical mine assumes 200,000 tons/day, which is more than is five times larger than this average.

  British Columbia includes five open-pit mines where Copper is the major or one of the major target minerals. The average milling rate for those mines is 56,120 tons/day. The EPA's hypothetical mine is almost four times that amount.

  While it is not possible to estimate the mine size for a ore body that has not yet been discovered, a comparison of mines in British Columbia and Alaska show that the EPA's hypothetical mine almost certainly is a gross overestimate of the likely size for any other yet to be discovered project. (Doc. #4612.2, p. 16).

Figure 1. Comparison of Milling Rate for Mines in Alaska/BC & EPA's Hypothetical Mine[13]



EPA Data. EPA's Assessment comes to a similar conclusion. Table 4-1 on page 4-2 of the Assessment compares Pebble to other copper porphyry deposits. The table shows that Pebble's tonnage is over 7 times greater than the 90th percentile of global copper porphyry deposits. EPA concludes that "The well-delineated Pebble deposit is clearly at the upper end of the total size range; any additional deposits found in the Nushagak River and Kvichak River watersheds would be expected to be one or two orders of magnitude smaller"
Summary. EPA's hypothetical mine may or may not accurately represent the disturbance area of Pebble. However, it almost certainly does not accurately represent the disturbance area of any other yet to be discovered large mine in the Bristol Bay watershed. This conclusion is based on a review of British Columbia and Alaska mines. EPA apparently comes to the same conclusion in Chapter 4 of the Assessment; yet the Assessment uses the large hypothetical mine to predict the impacts of other, much smaller, large-scale mines. (Doc. #4612.2, p. 16-17)

- ***EPA's Hypothetical Mine Uses a Non-Representative Location***
  EPA's hypothetical mine covers or blocks between 13.5 and 20.9 miles of anadromous fish streams. A GIS analysis prepared for this technical review tested whether the location for EPA's hypothetical mine was representative of other locations in the watershed. While the analysis prepared for this technical review is simple, it indicates that the location for EPA's hypothetical mine is likely to be a non-representative location. Locations available for other mines, even if they were the same size, may disturb a much lower acreage of anadromous

fish stream, or no acreage at all. It is even possible that alterative locations for facilities for a mine at Pebble would significantly decrease the impact on anadromous fish habitat. For that reason, the location of EPA's hypothetical mine cannot be considered to be necessarily representative of a location for potential other mines in the region, and possibly not representative of a mine at Pebble. To determine whether the particular location of EPA's hypothetical mine is representative of potential mining location around Bristol Bay watershed, the authors of this technical review worked with a University of Alaska student to conduct a simple, CIS review of locations in the watershed. The student used an algorithm to place an area that approximates a certain size mine disturbance throughout the watershed (excluding national and state parks). The object is to determine whether it is possible or likely to place a within the Bristol Bay watershed and not disturb significant lengths of anadromous fish streams. To approximate a mine disturbance, the student used two sizes: six and thirteen square miles. The six-square mile area is approximately the size of the disturbance at the Fort Knox Gold Mine, Alaska's largest open-pit mine. The thirteen-square mile area is approximately the size of the EPA's hypothetical mine (25-year mine life). The student found that, statistically, the vast majority of locations where one would randomly place these boxes in the watershed, it was possible to place them without disturbing an anadromous fish stream.

This procedure is obviously extremely rough. A more thorough analysis would have required EPA to extend the comment period. The analysis may exaggerate the frequency o mine locations that do not conflict with fish streams because many anadromous fish streams in the watershed have not been mapped. In addition, the simple analysis did not take into account the fact that tailings facilities are usually in valleys, and there is almost always a stream in the bottom of the valley (though not always an anadromous fish stream). However, it also did not take into account the ability of a mine to move facilities to avoid sensitive areas. Therefore, while it is not possible to conclude that other mines in the region-even other mines of the same size-would necessarily be locate-d so as to disturb far less anadromous fish habitat, the analysis makes it clear that there is a good chance of that occurring. (Doc. #4612.2, p. 18 to 19)

- **EPA's Hypothetical Mine Uses a Non-Representative Geochemical Make-up** There is no "typical" geochemical make-up for a metal ore that is representative of all deposit types within a region. Each deposit type and each deposit is unique. Therefore, the geochemistry of the Pebble deposit cannot be used to represent the geochemistry nor geochemical risks of other deposits in Bristol Bay. In addition, the EPA acknowledges that geochemical risk is dependent on human factors such as how waste rock and tailings are processed and stored. Given the diversity of options for doing so, it is possible that the eventual design for Pebble will choose a different system than EPA's hypothetical mine. Therefore, the geochemical risk and make-up of the hypothetical mine may not even represent Pebble. Courses on geochemistry emphasize that each ore is unique and must be analyzed individually. The courses emphasize geochemistry is influenced not only by natural factors-geology, climate, hydrology, etc.-but also involves human factors such as the processing methods, storage, etc. The EPA Sourcebook for Hardrock mining similarly emphasizes the diversity between deposits, or even within individual deposits, in that it requires that tests must be conducted on each geologic rock unit and each lithological unit. The authors of this technical review have been involved with mine permitting in Alaska. They have participated in state and federal requirements for statistical sampling throughout a mine pit because conditions can change in different locations within a pit or deposit. Indeed, there is no such thing as a typical geochemical make-up that represents all deposits or potential undiscovered deposits in the region.

Evidence of the importance of geochemical diversity can be illustrated by considering the Red Dog Zinc Mine which has enormous acid-generating potential and is reported to have 20% minerals in comparison to the Fort Knox Mine with close to zero reported sulfide minerals within the ore, no acid generating minerals, and limited leachable metals in the tailings water. (Doc. #4612.2, p. 19-20)

- In summary, geochemical character of ore deposits are unique. They are different for each deposit type. Even among copper porphyry mines, the geochemical characteristics cannot be predicted. The geochemical characteristics of the tailings, while having some similarities among copper porphyry mines, can vary significantly between deposits and are greatly influenced by the beneficiation techniques used by the mine. For this reason, the concept of a "typical" set of geochemical characteristics that would represent all deposits of various types in Bristol Bay is a fallacy. Such a typical set of characteristics does not exist.

  For that reason, the Assessment analyzes only the characteristics of the Pebble Deposit, not of any other deposit in the region. And even for Pebble Deposit, the Assessment focuses on the characteristics of the deposit itself, because it cannot predict the characteristics of the tailings without knowing the milling process-whether pyrite will be separated and how it will be contained-and without testing a synthetic generation of the resulting tailings. Therefore, while it is certain that the Assessment does not represent the geochemical make-up of other mines in Bristol Bay, because of the potential diversity in mine design factors, it may even not represent Pebble. (Doc. #4612.2, p. 20-21)
- **EPA's Hypothetical Mine Omits Mitigation and Prevention Strategies likely to be used by other large mines in Bristol Bay**; It is not possible to predict the mitigation and prevention techniques that will be used to protect the environment from exploitation of an ore deposit that has not yet been discovered. Given the large variety of techniques - from dry-stack tailings, shipping pyrite off-site, lining tailings impoundments, etc. - it would be unusual if any as-yet undiscovered mine used exactly the set of mitigation/prevention strategies that EPA assumes in its hypothetical mine. Therefore, it would be unusual for any mine to present the same stressors, or potential risk of stressors, for an undiscovered deposit. For that reason, the hypothetical mine is unlikely to present the same potential risks as other, as-yet undiscovered mines in Bristol Bay. (Doc. #4612.2, p. 21)
- **EPA Omits Mitigation and Prevention Strategies that would eliminate or significantly change the impacts it predicts for its hypothetical mine**. There are a number of changes in mine design that would eliminate or greatly reduce the impacts predicted in the Assessment. I t is wrong to assert that impacts from mining are inevitable when a design change would eliminate or greatly reduce the chance of such an impact. In addition, the hypothetical mine is effectively a pre-permitting design. The permitting process will force other, as yet unknown design changes. Analysis of a mine without those changes included will exaggerate adverse impacts and this is what EPA has done. (Doc. #4612.2, p. 21)
- EPA's hypothetical mine is effectively a pre-permitting design. We do not know whether Pebble will propose that design, or anything similar. However, based on experience at other Alaskan mines, it is likely that the proposed design will change and that prevention and mitigation strategies that are as-yet unknown to EPA, other agencies, or even the mining company will emerge. These strategies are usually required by the agencies, because they

will significantly decrease environmental impacts. A hypothetical mine, not subject to the permitting discussion, will incorrectly predict impacts. (Doc. #4612.2, p. 23)

- **EPA's hypothetical mine does not meet permitting standards. Therefore, it cannot represent realistic mine impacts for the watershed.** EPA assumes that the hypothetical mine would block or cover between 13.5 and 20.9 miles of anadromous fish streams and between 4.7 and 7.1 square miles of wetlands. It proposes no mitigation for these impacts. These non-mitigated impacts are inconsistent with permitting standards. The hypothetical mine also assumes that waste rock would be placed in an anadromous portion of Upper Talarik Creek. Given realistic alternatives, that placement would not be allowed. Thus, the hypothetical mine, as designed, would not be permittable under state or federal laws. A mine that does not meet permit standards cannot be taken as a realistic example of the impacts of mining. (Doc. #4612.2, p. 23)
- EPA's hypothetical mine design proposes to fill portions of Upper Talarik Creek with waste rock. This waste rock location does not fit the "last resort" practices of Alaska agencies and would not be allowed.
  The loss of wetlands without mitigation presents a similar issue. It is simply not realistic to cover between 4.7 and 7.1 square miles of wetlands with no mitigation and imagine that it could be permitted and would comply with Clean Water Act Section 404(b)(l) guidelines. (Doc. #4612.2, p. 24).
- **The Watershed Assessment lacks a realistic water budget.** The Watershed Assessment did not include a realistic water budget for the mine. A water budget is one of the most important documents a mine produces. It is influenced by the mining rate, tailings grind, and many other mine-design details. Agencies scrutinize water budgets during the permit process. A water budget typically goes through many iterations before the mine developer has confidence in it and before the agencies are willing to accept it. Until a water budget is final, and until the Department of Natural Resources proposes a water right volume, how much water the mine will need is unknown. Therefore, there is a lot of uncertainty about the impacts to downstream fish populations, until the water budget process is complete.
  The authors of this review cannot follow EPA's water budget. Therefore, we cannot comment on EPA's assertion of water withdrawal problems downstream of the mine. In addition, many groups have applied for instream-flow water rights on the Upper Talarik Creek, South Fork Koktuli River, and the North Fork Koktuli River downstream from the EPA's proposed location. EPA implicitly assumes that DNR will decide in favor of EPA's perception of the mine's water needs, and turn down the other applicant's for instreamflow water needs. We have no idea whether such an assumption is warranted. But neither does EPA. If EPA's unstated assumption is wrong, then the analysis is incorrect.
  In addition, water budgets are mine-specific. They are influenced by mine size, rainfall, processing method, etc. A water budget for a particular mine, hypothetical or not, is not representative of the water budget for another mine. Therefore, the water budget for the EPA's hypothetical mine (which is not produced adequately so that these authors can follow it) is unlikely to be representative of other mines proposed for Bristol Bay or elsewhere. (Doc. #4612.2, p.25-26)
- **Assumption of a Road**. A road may be required to develop the Pebble Mine. However, it is quite possible that other mines within the watershed would not be developed using a road, would use a shorter road, or would use a road in a less (or more) sensitive area. Thus, the road impacts may not be representative of non-Pebble mines in Bristol Bay. (Doc. #4612.2,

p.26)

- **Omission of Prevention and Mitigation Strategies-design changes for the road.** EPA proposes a specific road alignment and by implication road construction techniques and then disparages them because of the environmental impacts they will cause. The obvious solution is to provide a higher level of design/construction standards and a robust monitoring program to catch problems before they cause these problems. For example, they forecast that culverts will impact 10-14 streams. They omit the potential to install bridges (a prevention strategy). A bridge would eliminate the problems of hydraulic modification by failed or undersized culverts.
  Without detailed road design, maintenance, and inspection specifications, which are not included in the Assessment, it is not possible to determine the prevention and mitigation strategies necessary to eliminate or decrease the problems. However, EPA's pretense that these problems would not be identified during a permitting process and, if warranted, that additional prevention strategies, such as bridges, would not be required is incorrect.
  It may be possible that some of the areas that may be crossed by the road to the Pebble deposit are unusually sensitive to road interference. However, if this is the case, it is also likely that the agencies would require more effective prevention and mitigation strategies - i.e., higher road construction and maintenance standards. (Doc. #4612.2, p. 26-27)
- The decrease in mining sites on EPA's NPL list is a measure of success of the changing laws and practices. "Obviously and most importantly from the perspective of evaluating the success of Hardrock Mine regulation, none of the Hardrock Mines on the National Priorities List were approved after 1990." (Doc. #4612.2, p. 30)
- The Assessment relies on statistics gained from legacy mines to predict the operation of their hypothetical mine. Given the changes in practices and regulations explained above, this error is bound to overestimate the probability of failure. The Assessment appears to make this error throughout the document but especially in the dam failure, and possibly in the water treatment and collection failure (though in that section, they do not discuss, explain, or display the data used for their conclusion.) (Doc. #4612.2, p. 31)
- **The lack of design and the analysis omit prevention and mitigation strategies**. Alaska's mines generally have back-up systems in case effluent escapes from the primary containment mechanism. In some cases, the systems are inherent in the mine design; in some cases they are required by the agency permit process.
  At Fort Knox Gold Mine all parts of the mine drain to the tailings lake. Thus, the tailings lake will capture any upstream failure at the mill or the heap leach facility. The lake itself is a zero-discharge facility with downgradient pump-back wells. However, downstream of the tailings lake is a large constructed wetlands complex and a freshwater reservoir that would provide a large amount of dilution in case water evades the pump-back wells. This safe back-up system is inherent in the company's design. Fortunately, the back up has not been needed since the mine began; that is, no leachate has reached the wetlands/reservoir complex since the mine began operation in 1996.
  At the Pogo Gold Mine the water treatment system discharges into a constructed off channel treatment works. The system discharges into a constructed lake so that the treatment system water can mix without harming the adjacent Good paster River. This is a system with back-up safety built in. If monitoring the discharge shows a problem, the outlet of the lake can be blocked until the problem is fixed. The lake provides storage in case of a treatment system upset. If mixing is insufficient, more inlet water can be pumped into the mixing lake. The

company did not propose this system. In fact, it was forced on the company by the agencies during the permitting process, because it is such a safe system.
At the Red Dog Mine, all of the disturbed area-including the waste rock pile-drain either to the open pit or to the tailings lake. That way, all water can be controlled and treated before discharge. The unused volume in the tailings lake (i.e., freeboard at the dam) provides a margin of safety in case the treatment system must shut down.
The systems in these examples show how the potential for water collection and treatment failure can be minimized. None of these or other back-up system designs are discussed for EPA's hypothetical mine. The hypothetical mine is presented as if government evaluation almost did not exist: that is, the design appears to be a pre-permitting design (a design before government required margins of safety are enforced on the design). An accurate evaluation of water collection and treatment failure for the hypothetical mine must include realistic mitigation and prevention strategies. (Doc. #4612.2, p. 32 to 33)

- The Assessment speculates, "At mine closure, it is expected that acid-generating rock would be disposed of in the TSF or the mine pit. However, premature closure could leave waste rock piles in place" (emphasis added; p 6-37). Alaska mine regulations include a system of reclamation bonding that ensures the agencies have the funds to implement the reclamation plan if the mine closes prematurely. I t is an integral part for permitting all mines. (Doc. #4612.2, p. 34)
- **Assumption of a Pipeline**. A pipeline may be required to develop the Pebble Mine. However, no other mine in Alaska uses a pipeline. In fact, very few gold mines have a need for a pipeline because the gold is so much more compact than copper concentrate. Thus, it is statistically likely that other mines within the watershed would not use a pipeline. The predicted pipeline impacts are unlikely to be representative of non-Pebble mines in Bristol Bay. (Doc. #4612.2, p. 36)
- **Omission of Pipeline-related Prevention and Mitigation Strategies**. EPA's pipeline design omits obvious prevention and mitigation strategies. EPA assumes that any spill within 100 feet of a stream could flow to that stream. If so, then moving the pipeline further away from the stream should solve the problem. Other strategies might involve building a berm for containment, or other methods to keep a pipeline spill from entering a stream or wetland. (Doc. #4612.2, p. 36)

<u>Millrock Resources Inc. (Doc. #4828.2)</u>

- **Failure to consider Modern Best Practice and Minimizing Limitations**: The Assessment ignores modern-day mining practices and takes extreme liberties in minimizing the study's identified limitations. Rather than addressing the limitations, the Assessment proceeds to perform unrealistic analyses on sensationalized scenarios for hypothetical mining projects. Secondary prevention, mitigation and reclamation measures are not even considered in the Assessment. The Assessment does not utilize sensible mining practices. For example, the Assessment, which depicts a hypothetical TSF for Millrock's Humble prospect directly over Napotoli Creek -something a mining company or regulatory agency would not seriously consider. The Assessment identifies and evaluates early-stage exploration projects, such as Humble, as potential mines under Cumulative Effects and excludes them from the Summary of Uncertainties. The material depth of the Summary of Uncertainties stands alone as proof that the Assessment makes unrealistic suppositions. (p. 3)

The Pebble Limited Partnership (Doc. #4960 and 4962)

- Inexplicably, EPA's Assessment barely acknowledges the likelihood that extensive mitigation efforts will eliminate or reduce the probability of adverse effects. Of course, any modern mining project that would ultimately be permitted would implement extensive mitigation measures, many of which are not and cannot be anticipated in the Assessment. The uncertainty about mining operations and mitigation at this stage compels the conclusion that the Agency does not (and cannot) know whether any potential impacts will necessarily occur should mining of the Pebble prospect ultimately take place. (Doc. #4960, p. 18)
- **Tailings dams.** Tailings dams in Alaska must be designed and constructed to the highest standards, as required: (a) by a strict regulatory process that is already in place through the Alaska Dam Safety Program; (b) by the use of appropriate hazard classification processes to assign appropriately conservative design criteria; and (c) by corporate commitments for meeting or exceeding all regulatory requirements. State-of-the-practice engineering design methods need to be applied along with appropriate construction methodologies, coupled with regulated requirements for oversight and quality control. Dam safety inspections, on-going monitoring, and regular reviews are required to continue well after mine closure to ensure that these objectives are satisfied. The Assessment mistakenly suggests that these fundamental permitting requirements will not be applied to a potential development within the Bristol Bay watershed. This is a fundamentally flawed premise. It is also extraordinary that an EPA document would suggest that this is a reasonable basis for its impact assessment, because it assumes that a federal regulatory process would completely ignore modem standards for tailings dams. The Assessment does not take into account these modern design criteria. (Doc. #4962, p. 4)
- **Waste rock piles.** The design and construction requirements for waste rock piles include the development and evaluation of a hazard rating for the rock pile. The disposal of waste rock in Alaska is regulated by the Alaska Department of Natural Resources (DNR) under Alaska Statute 27.19. The regulations address stability, acid rock drainage, and long term reclamation requirements. Furthermore, the EPA and RCRA also provide guidelines for: Waste rock pile configuration options Preliminary design considerations, such as waste rock characterization and site characterization Stability factors, such as foundation stability and waste rock pile Stability Construction and operation methodologies Monitoring methods, and Closure and reclamation requirements. These standards and regulatory guidelines should be the building blocks for the development of any hypothetical mine scenario, yet the Assessment ignores them. (Doc. #4962, p. 4 to 5)
- **Water Management and Mitigation**. The Assessment indicates that the assumed mining operation would modify natural runoff and infiltration, but fails to highlight the extensive studies that are required to understand baseline conditions and to determine the changes to flow conditions during construction, operation and after mine closure. These studies are fundamental requirements for the permitting process, and are required to determine appropriate mitigation measures to ameliorate potential impacts. The Assessment Report fails to incorporate reasonable mitigation measures and therefore does not represent a realistic mine development scenario. The Assessment is written as if these well-established standards did not exist. (Doc. #4962, p. 5)
- **Roads and culverts**. As described in detail in several state and federal sources, modern stream crossing and culvert standards foster designs that are self-sustaining, durable, and provide continuity of geomorphic processes such as the movement of debris and sediment.

National Marine Fisheries Service (NMFS) design criteria require that all fish passage facilities be designed for the 100-year flood event (2001) and that any potential damage to the crossing be addressed as part of the design process. These design criteria reduce the potential for culvert failure, both from blockage of fish passage and road washout, and promote habitat and fluvial process continuity. (Doc. #4962, p. 5)

- **Reclamation bonding**. The Assessment implies that mine closure will be inadequate and that the owner will not be responsible for environmental liability. This assumption is not realistic: comprehensive analyses and adequate bonding to maintain the site in perpetuity, including monitoring, maintenance, and upgrading or replacement of treatment systems as new technologies are developed, would be necessary before any development could be permitted to proceed. (Doc. #4962, p. 6)
- Section 4.3.8.5, page 4-33, paragraph 3. This text implies that environmental protection requirements imposed when a mine is opened may not be required when it is re-opened. While the permitting requirements may change, they will not change without evidence provided to state and federal authorities that the changes will not result in significant environmental impacts. Over time, in fact, environmental standards typically become more stringent. (Doc. #4962, p. 19)
- Section 4.3.7, Page 4-26, first paragraph. The likely impacts of a mine on hydrology will vary with the location of the mine, the local topography and hydrologic patterns, and the mitigation activities undertaken to minimize or avoid impacts to hydrology. The assessment ignores these realities. (Doc. #4962, p. 19)
- Section 4.3.7, Page 4-27. Last paragraph, 1st sentence. The statement assumes that surface water flows would be reduced. The reduction in water flow will be dependent on the location of the mine, the sources of water used in the mine, the connectivity between surface and groundwater sources, etc. The assessment fails to convey clearly how these and other related factors, some of which are unrelated to mining activities, influence surface water flows. (Doc. #4962, p. 19)
- Section 4.3.8, paragraph 1, sentences 2, 3, and 4. The discussion of other possible mitigation options and discussion of the effect of location, surface and groundwater quantities, and topography on the potential effects is inadequate. The text in this section, as well as in other sections, fails to address the positive effects that prevent or minimize the types of environmental risks that the assessment has focused on. (Doc. #4962, p. 19)
- Section 4.3.8.1, page 4-31, second paragraph, sentence 2. This section makes assumptions regarding the composition of the ore and also assumes that the ore will not be sealed against oxidation. This may or may not be accurate. There is insufficient information in the document explaining what is known and not known about the ore and why it is reasonable to assume the ore will not be sealed against oxidation. If significant effects are anticipated, it is reasonable to assume that restoration activities will likely require actions to mitigate this effect. (Doc. #4962, p. 19)
- Section 4.3.8.2, page 4-32, paragraph 2, sentences 5, 6, and 7. This discussion is based on the assumption of an absence of mitigation measures and a failure to address long-term impacts in the restoration plan. This is an incorrect assumption and is contrary to current mining practices and long-term planning requirements. This incorrect assumption negates the overall analysis. (Doc. #4962, p. 19)
- Section 4.3.8.4, page 4-33, first paragraph, first sentence. Specific mitigation and restoration

requirements are likely to require restoration of downstream flows; the statement in the assessment is based on an assumption that may not be correct. There is insufficient information in the assessment to support this assumption. (Doc. #4962, p. 19)

- Section 4.3.8.5, page 4-33, paragraph 2. The text assumes that a mine owner can abandon a site with no consequences. While this may have been the case in the last century, it is no longer the case today. The State of Alaska requires a bond to cover the cost of restoration actions in the event the mine owner defaults. The bond assures that monies are available for restoration. Sections of the text that assume it is possible to abandon a mine site without consequences need to be revised in light of State of Alaska bond requirements {see e.g., Alaska Statute 27.19 &Alaska Administrative Code Chapter 97). (Doc. #4962, p. 19)
- Section 4.3.9.2, 1st paragraph, 1st sentence; Table 4-6; page 4-37 paragraphs 1 and 2. The majority of this paragraph needs to be restated as an assumption; the source of information is not specified, and the information needs to be presented as assumed. (Doc. #4962, p. 20)
- Section 4.3.9.1, page 4-36, last Sentence. The fact that culverts washed out may not be pertinent to the assessment since it is not clear that the culverts that washed out were constructed in accordance with today's standards and best management practices. This is another example of reliance on invalid assumptions and inappropriately applied mine scenarios. (Doc. #4962, p. 23)
- Section 4.3.7. This section makes numerous statements regarding the expected impacts of a mine on hydrology. Citations are missing describing the source of these assumptions. (Doc. #4962, p. 30)
- Section 4.3.7, Page 4-26.3rd bullet. Other approaches to managing precipitation are possible; the absence of a consideration of other options to manage precipitation and the supporting literature describing possible actions should be corrected in order to facilitate evaluation of the significance of the assumption. (Doc. #4962, p. 30)
- Section 4.3.8.1,page 4-31, sentence 1. Citations are missing describing the source of these assumptions. (Doc. #4962, p. 30)
- Section 4.3.8.4. Several references are made to Table 4-5; the information in Table 4-5 is not supported by references or any discussion regarding data analysis. (Doc. #4962, p. 30)
- **Mine Scenario** The Assessment Report presents a mine scenario and assumptions that fail to meet the standards for mine development and environmental assessment in the State of Alaska and the United States of America. The Assessment Report includes a flawed risk assessment that draws false conclusions based on past examples from other jurisdictions and mining practices that are not permitted in the State of Alaska. The Assessment Report states that "the assessment largely analyzes a mine scenario that reflects the expected characteristics of mining operations at the Pebble deposit". In fact, the EPA grossly underestimates the high standard to which a mine in the Bristol Bay watershed would have to be designed and engineered in order to obtain permits to operate in the watershed. It also underestimates the role of various federal and state regulatory agencies in the permitting process that will help ensure that a technically advanced mine would be designed and operated. The Assessment Report is based on a fundamentally flawed premise that a faulty mine design, inadequate mine development and inappropriate mine operations would be permitted to occur within the State of Alaska, and specifically within the Bristol Bay watershed. The Assessment Report has misrepresented the likelihood of tailings dam failure for any proposed mining development in Alaska. It has also utilized unrealistic and erroneous

extrapolations to develop questionable predictions of potential impacts of mining operations within the Bristol Bay watershed. (Doc. #4962, p. 40).

- **Permitting In Alaska** Tailings dams in Alaska must be designed and constructed to the highest standards, as required by a strict regulatory process that is already in place through the Alaska Dam Safety Program; by the use of appropriate hazard classification processes to assign appropriately conservative design criteria; and by corporate commitments for meeting or exceeding all regulatory requirements. State-of-the-practice engineering design methods need to be applied along with appropriate construction methodologies, coupled with regulated requirements for oversight and quality control. Tailings impoundments must be designed, constructed and operated to achieve and maintain performance objectives and to form stable long-term landforms in perpetuity. Dam safety inspections, on-going monitoring, and regular reviews are required to continue well after mine closure to ensure that these objectives are satisfied.
  The Assessment Report suggests that these fundamental permitting requirements will not be applied to a potential development within the Bristol Bay watershed. This is not only a fundamentally flawed premise, but it is also somewhat confusing that an EPA document would suggest that this is a reasonable basis for their impact assessment, since they are suggesting that a federal regulatory process would allow an inappropriate or inadequate development to proceed. (Doc. #4962, p. 44)
- **Water Management** The Assessment Report indicates that the assumed mining operation would modify natural runoff and infiltration, but fails to highlight the extensive studies that are required to understand baseline conditions and to determine the changes to flow conditions during construction, operati6ns and after mine closure. These studies are fundamental requirements for the permitting process, and are required to determine appropriate mitigation measures to ameliorate potential impacts. The Assessment Report fails to incorporate reasonable mitigation measures and therefore does not represent a realistic mine development scenario. (Doc. #4962, p. 45)
- **4.3.8.2: 4-32.** We assume that water in the TSFs would be drawn down to prevent flooding, but that a small pond would be left to keep the core of the tailings hydrated and isolated from oxidation. Sulfide-rich materials that would generate acid if exposed to oxygen would have been placed in the core of the tailings impoundment. As long as a stagnant cover of water is maintained, oxygen movement into the tailings would be retarded, minimizing acid generation. Drawing down the level of water in the TSF would also provide capacity for unusual precipitation events, reducing the likelihood that a storm would provide enough precipitation to overwhelm capacity and cause tailings dam failure or overtopping.

THIS IS AN EXAMPLE OF HOW TO PREVENT OVERTOPPING FAILURE FROM THE ASSESSMENT REPORT THAT CONTRADICTS THE SUMMARY AND CONCLUSIONS OF THE STUDY. (Doc. #4962, p. 47-48)

- **4.3.8 Post-Closure Mine Management: 4-31** Weathering to the point where these contaminants are present in only trace amounts (at levels approaching their pre-mining background concentrations) would likely take hundreds to thousands of years, resulting in a need for management of materials and leachate over that time. We assume that, as part of post-closure operations, the existing seepage collection and treatment system would be maintained to capture and treat potentially toxic runoff and groundwater originating from the remaining facilities. Such a seepage collection and treatment system might need to be maintained for hundreds to thousands of years. There are no examples of such successful, long-term collection and treatment systems for mines, because these time periods exceed the lifespan of most past large-scale mining activities, as well as most human institutions. Throughout this section, we refer to the need for treatment for extended periods of time. The uncertainty that human institutions have the stability to apply treatment for these timeframes applies to all treatment options.

THIS IMPLIES THAT MINE CLOSURE WILL BE INADEQUATE AND THAT THE OWNER WILL NOT BE RESPONSIBLE FOR ENVIRONMENTAL LIABILITY - THIS IS NOT REALISTIC AS COMPREHENSIVE ANALYSES AND ADEQUATE BONDING TO MAINTAIN THE SITE IN PERPETUITY, INCLUDING MONITORING, MAINTENANCE, AND UPGRADING OR REPLACEMENT OF TREATMENT SYSTEMS AS NEW TECHNOLOGIES ARE DEVELOPED, WOULD BE NEEDED BEFORE ANY DEVELOPMENT COULD BE PERMITTED TO PROCEED. (Doc. #4962, p. 48-49)

Alaska Oil and Gas Association (Doc. #4974)

- NEPA requires the analysis of various alternatives as well as the use of mitigation measures to minimize environmental impacts. Instead, EPA analyzed the impacts of a single hypothetical mine project, with little to no discussion about specific mitigation measures, based on a very small amount of information compared to the vast amounts of science available for Pebble. The law also requires EPA to consider the benefits of proposed projects, which it did not do here. (p. 2)

Bristol Bay Regional Seafood Development Association (Doc. #4151.2)

- We note and agree that even under a No-Failure scenario, the fisheries suffers significant impact from the hypothetical mine. Regarding that hypothetical mine; we also note that the document is erratic in referring to the size of the Pebble-based hypothetical mine. This is significant because the impacts of large-scale mining are proportionate to a mine's size. Applying a smaller size understates potential impacts. In many instances the Assessment's mine scenario is based on a 6.5 billion ton mine. Yet in other sections (e.g. Section 4.1.1.), the document refers to the more likely 10.8 billion ton mine – an estimate created by Northern Dynasty in their 2011 Wardrop report. We believe, therefore, that the document's sound but appropriately cautious approach to mine size significantly underestimates probable impacts on salmon. Regardless, even under a "smaller" but still giant 6.5 billion ton mine – the impacts are enormous and promise severe consequences to the salmon resource upon which our businesses and jobs depend. (p. 1 to 2)

Dave Aplin – World Wildlife Fund (Anchorage Public Hearing)

- And if I might just add, fugitive dust is important. Additional look a t seismic activity is important and looking at the infrastructure that will develop and the secondary and tertiary impacts is all important work to do. (p. 112 of the public hearing transcript).

Alaska Marine Conservation Council (Doc. #4112.2)

- Mine scenarios also underestimate cumulative impacts that would occur with the build-out of a single mine, as the study scope was limited and did not include impact assessment of power, port, transportation, and human infrastructure development that would likely occur. (p. 2)

Fisheries Research & Consulting (Doc. #4580.1 and 4580.2)

- The maximum mine scenario is conservative. Pebble mine proponents consistently base job projections and economic benefits of mining Pebble on the full exploitation alternative (11 billion metric tons). This alternative would result in a mine almost twice as large as the EPA maximum scenario, which would have a greater impact on aquatic resources. To fully disclose potential impacts to policy makers and the public, it is reasonable to consider a third mine scenario based on exploitation of the estimated 11 billion metric ton Pebble deposit. (Doc. #4580.1, p. 1 to 2)

p	pdf page	Quote	Comment
4-6	95	Figure 4-2	In 2005 Northern Dynasty published a graph of acid generating potential of samples from Pebble West in Chapter 8 of their 2004 progress reports. The graph showed that the majority of samples had high potential for acid generation.
4-16	105	Table 4-4	Add Pebble
4-18	107	Figure 4-6	Legend and figure are mismatched
4-21	110	much higher than most existing tailings dams	Can you add an average tailings dam height for other dams worldwide and/or in the US? It would be helpful throughout this chapter as well as associated figures
4-23	112	In a TSF, the low solubility of oxygen in the waer (less than 15 mg/L) limits the access of oxygen to unreacted sulfide minerals in the tailings, reducing dissolution reaction rates and th thus the concentation of solutes.	What about PLP's data indicating saturated groundwater? What if that is upwelling into TSF?
4-23	112	carbonate or silicate minerals will partially neutralize acid	This is not the case at Pebble, if I understand
4-42	131	Figure 4-11	Has an earthquake closer to the Pebble deposit been recorded here?
4-54 - 4-59	143	Tables 4-10 - 4-13	Would be nice to have a map/graphic for visualizing 'downstream extent of model,' failure volumes, and/or some of the depth and volume scenarios
4-60	149	We limited our model to 30 km above the confluence of NFK & SFK	Isn't that AT the deposit practically?

p	pdf page	Quote	Comment

		NFK & SFK	
4-60	149	The probability of a pipeline failure occurring over the duration of the minimum mine scenario (i.e., approximately 25 years) would be 98% for each [of the four] pipelines	Virtual certainty of pipeline failure
4-64	153	Fig. 4-14	Move up to refer to text; clarify--figure is confusing

(Doc. #4580.2, p.8)

Ground Truth Trekking (Doc. #3772.1)

(Note: By "Box 3-4", the commenter means "Box 4-3")

- Comment 1: The Watershed Assessment does not describe the general seismic environment of Bristol Bay. In Box 3-4, the first paragraph lists off some major faults, and the second paragraph provides some information on studies of the Lake Clark Fault. What is missing is the broader geological context. The region surrounding Bristol Bay is potentially impacted by as many as four independent and actively moving blocks of crust (Haeussler 2008). The most dramatic motion in the region is likely driven by subduction of the Pacific Plate to the south under North America to the north. A fragment of the North America Plate called the Southern Alaska Block is sliding west along the Denali Fault and others, driving earthquakes east of Bristol Bay and its impact on the Bristol Bay Region is unknown. Finally, a section of rotating crust called the Bering Block may be shearing along the western edge of Alaska, possibly impacting Bristol Bay (Macket et al., 1997). This complex tectonic context makes it difficult to extrapolate tectonic trends from elsewhere in the state to the area. (pp. 1-2)
- Comment 2: Some inaccurate characterizations and irrelevant material obscure the general status of research on seismic hazards. Box 3-4 states, "The western terminus of the Lake Clark Fault was originally interpreted to be near the western edge of Lake Clark, but more recent studies by USGS reinterpreted the position of the Lake Clark Fault further to the northwest, potentially bringing it as close as 16 km to the Pebble deposit (Haeussler and Saltus 2005)." No scientific work has been done to ascertain the terminus of the Lake Clark Fault. The terminus is explicitly unknown. No evidence discovered to date has suggested or been interpreted as a terminus. Haeussler and Saltus map the fault to about 16 km short of the Pebble deposit, but their results do not suggest it terminates there. On the contrary, they show that there is about 26 km of offset on the Lake Clark Fault, similar to what is seen further northeast. This offset implies the fault must go further or transition into some other unknown fault system. Likewise, the characterization of the length of the fault as 225 km long is inaccurate. As an important distinction, the length mapped is 225 km. Additionally, Box 3-4 includes discussion of the "Braid Scarp" feature. This is just a single ancient riverbank that, though it was investigated as a possible fault trace, is not in fact a fault. This has no implications as far as the broader tectonic behavior of the area, and has no relevance in the document. (p. 2)
- Comment 3: The Watershed Assessment does not make the uncertainty about seismic hazards clear. The most recent scientific literature (Haeussler & Waythomas 2011, Koehler & Reger 2011) on seismic hazards along the Lake Clark Fault and in Bristol Bay clearly equivocates. Little is known, the hazard is thus undetermined, and the researchers make

carefully worded statements to reflect this. This is a key factor when assessing future developments in the area. Published research suggests that seismic hazard may be low, but the extent of this research is limited, and seismic hazard may be high. We found this important scientific distinction was lost in Watershed Assessment. Perhaps the most relevant and recent paper on the subject, is Koehler and Reger, 2011. Koehler & Reger conclude that they did not find evidence for activity on the Lake Clark Fault in the Tyonek area in the recent past, paralleling the results summarized by Hauessler & Waythomas (2011). In addition, they clearly articulate the state-of-knowledge of the western end of the Lake Clark Fault, near Pebble: "The paleoseismic history of the western part of the Lake Clark fault remains unknown." Koehler & Reger also clearly describe some of the limitations to knowledge of the Lake Clark Fault's activity level. For instance: "…distributed slip on unrecognized structures and dense vegetation that might obscure tectonic features along the Lake Clark fault could limit assessment of tectonic activity." Together, Koehler & Reger (2011) and Haeussler & Waythomas (2011) well-characterize the overall state-of-knowledge, but this requires careful reading. There is no currently public evidence to suggest recent activity on the Lake Clark Fault, but there is also little scientific knowledge on the subject, and broad conclusions about the seismic stability or history of the area are preliminary. Koehler & Reger 2011 is actually cited in the current version, but this is an accidental mis-reference: the paper referred to in the current version is actually Koehler 2011, which is Rich Koehler's review of the Braid Scarp. (p. 2)

- Comment 4: Minor technical correction on small & induced earthquakes. Box 3-4 states that earthquakes may occur "…outside of pre-existing faults." It would be more accurate to say such earthquakes can occur on previously unidentified, minor, or otherwise inactive faults, but it's very unusual for manmade stresses to cause the formation of new faults. (p. 3)

Center for Science in Public Participation (Doc. #4106.2 and 4122.2)

- In this section the minimum and maximum mine scenarios (2 billion tonnes and 6.5 billion tones respectively) for the Pebble Project used in the Draft Assessment are described. Northern Dynasty Minerals has published a total resource estimate (measured, indicated, and inferred) of 10.78 billion tonnes. Since this estimate is used in part to attract potential investors in the project, it must be a legally defensible mineral resource estimate. This 'maximum' Pebble Project is mentioned in the Section 4.3.2 of the Draft Assessment, but many readers will only view the Executive Summary. (Doc. #4106.2 , p. 2)
- It is noted that: "Dry stack tailings management, in which tailings thickened to a paste and filtered are "stacked" for longterm storage, is a newer, less commonly used tailings disposal method. Dry stacked tailings require a smaller footprint, are easier to reclaim, and have lower potential for structural failure and environmental impacts (Martin et al. 2002)." (Draft Assessment, p. 4-13, emphasis added). In the terminology that is in common use today, "filtered" and "paste" tailings are two different things. Filtered tailings have enough moisture to allow the majority of pore spaces to be water filled but not so much as to preclude optimal compaction of the material. Water is removed from filtered tailings with vacuum or pressure filters. Paste is simply dewatered tailings with little or no water bleed that are non-segregating in nature. Paste tailings typically utilize a thickener-type dewatering process which is less expensive than filters, but removes less water. The water content of paste tailings lies in between conventional slurry tailings and "dry" or filtered tailings. (Doc. #4106.2 , p. 3)

- It is noted that: “Water leaving the site via surface runoff or through groundwater would require capture and treatment for as long as it does not meet water quality standards.” (Draft Assessment, p. 4-31) A key aspect of post-closure hydrology is that groundwater flow will be away from the pit, waste rock, and tailings (as shown in Figure 4-9). Seepage collection systems are notoriously inefficient (even ineffective), and expensive to operate if pumping is involved. This vector often leads to long term contamination of downgradient surface waters, and could impact these waters for centuries. Although it is implied in this statement, it is not explicitly stated that groundwater flow from the mine pit, waste rock, tailings (and underground workings), at Pebble would most probably be away from the mine workings (because of the location of the mine workings at the top of the hydrologic divide, and because there is little evaporation at this location). (Doc. #4106.2 , p. 4)
- The mine scenario is set up well, with the exception of data gaps in discussion of water treatment and underground mining. These data gaps deserve fuller discussion, provided in separate sections after the “Mine Scenario” comments below.
    - Add to make more complete. The “identities of ore processing chemicals are unknown, so potential toxicity is not considered” (“Uncertainties”, Assessment Section 5.3.4) EPA is setting up a hypothetical mine scenario, and includes chemical “storage and transport” in the conceptual models. Ghaffari et al 2011 Sections 16.4.3 and 16.9.4 mentions specific chemicals that will likely be utilized at Pebble, and it is reasonable to assume they would also be used at other mines. It is worth providing a list of likely chemicals. Limiting the risk assessment by not including the chemicals again underscores the conservative approach of the Assessment.
    - Good visual of ore processing (Assessment Figure 4-4)
    - The figure of the tailings dam (Assessment Figure 4-8) could include comparison to dams at mines in Alaska (e.g Fort Knox, 111m, Red Dog 63m; Levit and Chambers 2012), or common Alaska landmarks (Conoco-Phillips Building 90m, Atwood Building 81m; www.emporis.com).
    - A legend should be placed on each of the conceptual model figures
    - Assessment Section 4.3 references Table 4-4, a comparison of a Pebble-sized mine to other mines in Alaska. Another table should be developed that compare the ore body to global copper porphyry mines, former and existing (Cooke and Hollings 2006; www.resourceinvestor.com/2010/06/28/sizing-up-the-worlds-mega-coppergold-projects) (Doc. #4122.2, p. 3)
- There is a data gap concerning Water Treatment. Despite discussions of mine/waste facility sizes and details, there is no discussion of water treatment plant options and methods, outside of a very cursory summary in Appendix I. While the Northern Dynasty report that much of the Assessment details are drawn from (Ghaffari et al 2011) is weak on details of a water treatment plant, a plant is essential to the operation of a mine, and the broader subject should be discussed in Appendix I.
    - Add to make more complete. A discussion of water treatment options is warranted to allow the reader to understand constraints (EPA 2006a). This should include a discussion of passive treatment (EPA 2006 Section 4.2.3; EPA 2006b). While passive treatment was mentioned in Appendix I2, this method is not an option at a large scale sulfide mine, which will have high flows and metal concentrations much too large for passive treatment to handle.

- Comment on presentation. Assessment Section 4.3 mentions that water quality in operations will be a mix of mill slurry supernatant, background (represented by the North Fork Koktuli) and oxidation leachate, and references the reader to Assessment Appendix H. The tables in Appendix H should be summarized in tables or boxes in this section. (Doc. #4122.2, p. 3 to 4)

Stratus Consulting (Doc. #4973)

- **Estimating the geochemistry of tailings and waste rock (pp. 4-23–4-24).** The Draft Watershed Assessment states that the leachate compositions from tailings humidity cell tests (HCTs) are a worst-case scenario because the tests are conducted in an aerobic environment. However, the subaqueous column tests, which were not conducted under aerobic conditions, showed that material that oxidized before the tests were conducted had low pH values and elevated concentrations of cadmium, copper, nickel, and zinc even when submerged (see Appendix A, p. 14 and Figure 7). These results suggest that if acid generation starts, submerging the mined materials (waste rock, tailings, or pit wall rock) under water (in a non-aerobic environment) might not be successful in stopping it. In addition, discussion of tailings leachate chemistry in the Draft Watershed Assessment does not seem to consider the HCT results from the one pyritic tailings HCT sample. In that sample, although the pH did not drop below 7 for the length of the test, the pyritic tailings had the highest leaching rates and concentrations of beryllium, cobalt, nickel, selenium, silver, thallium, and zinc of any of the 2008 tailings HCT samples (PLP, 2011, Appendices 11L and M; Appendix A, p. 9). Including the results from the one pyritic tailings sample HCT is important because Ghaffari et al. (2011) estimate that pyritic tailings will comprise approximately 14% of the tailings waste stream. (p. 5)
- **Assumptions about pit water quality (p. 4-32).** The Draft Watershed Assessment assumes that covering of acid-generating wastes or pit walls with water during closure will eventually stop acid generation below the water level in the open pit during and after closure (p. 4-32). Two observations argue against this assumption: the results of the submerged column tests, as discussed in the previous bullet; and the water quality of the Berkeley Pit in Butte, Montana. The potentially acid-generating portions of the walls of the open pit will be exposed to oxygen and runoff for decades before closure. Therefore, they are highly likely to be oxidized before being submerged. The submerged column test samples conducted on the two most abundant Pre-Tertiary rock types, mudstone and granodiorite (which had only moderate sulfide contents) went acidic quickly and leached high concentrations of metals and acidity, as noted above. For comparison, the Berkeley Pit in Montana, which was created from the mining of another porphyry copper deposit, has low pH values (< 2.8) at all depths and copper concentrations between 50 mg/L in surface waters of the lake and ~ 200 mg/L at depth (Davis and Ashenberg, 1989; Gammons and Duaime, 2006; Gammons et al., 2006). At low pH values (below approximately pH 3.5), such as those generated by leaching of Pre-Tertiary mudstone and granodiorite, ferric iron ($Fe3 +$) is present and is a stronger oxidant than oxygen; ferric iron can exist under low or no oxygen conditions at these pH values (Nordstrom, 1982; Plumlee, 1999). In contrast to the low pH and high copper concentrations of Berkeley Pit water, the adjacent underground workings have near neutral pH values, and copper concentrations have been decreasing over time to low parts-per-billion levels (pumps were turned off in 1982). Values are somewhat higher in the Kelley Shaft (~ 100 µg/L), which connects with the pit, was block caved, and likely received acidic inputs from copper

dump leaching operations (Gammons et al., 2006). These results suggest that neutralizing acidic waters after closure by submerging under water would be more successful in the underground workings than in the pit lake. The final Watershed Assessment should revisit assumptions about the effectiveness of submerging mine wastes and pit walls under water when these materials have already been oxidized. Another qualitative analysis of pit water quality on p. 6-40 seems to contradict the assumptions on p. 4-32, and these two pit water quality assumptions should be made more consistent. (p. 5-6)

Ecosystem Ecologist (Doc. #3806.1)

- I know the mine description is hypothetical at this point. But I am very concerned about the size of this mine. The sheer size of this mine means there will be an enormous amount of tailings. Properly dealing with those tailings is going to be a challenge, but it is absolutely key that tailings be handled in as careful a way as possible using the most advanced technologies available for protecting nearby habitats and water quality. This means ensuring there is no leakage by using the best available technology for lining the drainage and storage ponds and planning for extreme events that may not currently be occurring but may occur in the future. I have concerns that the size of the waste stream from this mine will mean that the waste, including the tailings, will be very challenging to deal with them using the utmost safety requirements including fully lining any storage basins. So, I am very concerned about the idea that the tailing ponds might be unlined (p 4-21 "The TSF would be unlined other than on the upstream dam face, and there would be no impermeable barrier constructed between tailings and underlying groundwater.") I believe the size of this mine may actually make it very difficult to make the conditions necessary for safe mining to exist. (p. 3)

J.P. Tangen (Doc. #4583.1)

- EPA purports to be analyzing the impacts of large-scale mining in the Bristol Bay watershed. Since the Pebble Project has not released a mining plan, the analysis ostensibly is not about Pebble; however, the thinly veiled hypothetical mine that is discussed unmistakably is the evil shadow of what a Pebble proposal might look like. In brief, however, the hypothetical mine neither resembles anything Pebble could ever imagine – an unpermittable project – nor does it correspond with any other imaginable project in southwest Alaska or anywhere else in the country. (p. 1)
- EPA's hypothetical mine over-estimates the size of likely mines in Bristol Bay by more than 5 times the average open-pit mine in Alaska and British Columbia, and more than 4 times the average copper mine. (p. 1)
- EPA's hypothetical mine uses a non-representative geochemical make-up. There is no typical geochemical make-up for a metal ore that would be representative of all ores within a region; therefore, the geochemistry of one deposit cannot be used to represent the geochemistry or geochemical risks of other deposits in the area. (p. 2)
- EPA's hypothetical mine omits mitigation and prevention strategies that necessarily will be used by any large mines in the Bristol Bay watershed. Given the large variety of mitigation and prevention techniques available to today's mining industry, it would be an extra-ordinary coincidence if any as-yet undesigned mine used exactly the set of mitigation/prevention strategies that EPA assumes in its hypothetical mine. (p. 2)
- EPA omits mitigation and prevention strategies that would eliminate or significantly reduce the impacts it predicts for its hypothetical mine. These include such strategies as dry tailings

closure and moving the product by pipeline. (p. 2)

- EPA's hypothetical mine does not meet minimum permitting standards because the design used by EPA includes no mitigation provisions for eliminating anadromous fish habitat and wetlands impacts. Waste rock cannot be placed in such a creek under state or federal regulatory standards. Accordingly the hypothetical mine as proposed by EPA could not be permitted. (p. 2)
- EPA overestimates the realistic mine size. The habitat modification description in the Assessment is a direct consequence of the mine size and location. As EPA over-estimated the mine size for other mines, the habitat modification impacts are significantly overestimated. (p. 2)

<u>Carol Ann Woody (Nondalton Public Hearing)</u>

- If anything, I think your assessment of the potential impacts of mineral development f to fisheries resources actually is very conservative, almost too conservative. The reason I think this is that you assume that the Pebble prospect would only develop 6.5 tons of their 10.8 billion ton estimated resource. Because all estimates of the mineral wealth, jobs and benefits from that particular resource are based on full exploitation of the 10.8 billion tons. The watershed assessment should consider impacts of expansion to the 10.8 billion ton Pebble Mine scenario. Mines will generally expand and expand as long as they are economically viable, as do the impacts. (p. 14 of the public hearing transcript)

<u>Sheila Wehmeyer (Doc. #3486)</u>

- Example tailings dam height (Figure ES-8) is compared to St. Louis Gateway Arch and the Washington Monument. Using familiar landmarks for comparison of height is understandable but comparison of a dam to these structures is not reasonable. The Hoover dam would be a better comparison in terms of structure type (dam) and height (221 m) but would still be inappropriate as it is not an embankment dam. Similarly a landform such as a local hill or mountain would be more appropriate than the examples selected in the EPA document. (p. 4)
- The hypothetical mine scenario used in the draft Assessment wouldn't be permitted under existing standards. (p. 5)
- Table 4-2 also provides for "premature" closure. Due to the reclamation bonding requirements in the State of Alaska (which requires timely reviews and updates), it is unrealistic to consider any closure that does not also include some form of "planned site management." That, of course, is the primary purpose for States requiring a reclamation bond. (p. 5)
- No exposure to or design input from AK industrial developers. For instance, in section 4.2.3 (page 4-11) the author states that geomembrane technology has not been available long enough to predict service life, based on personal communications with a single geomembrane supplier and a modified bitumen roofing supplier. Significant data on geomembrane service life are almost certainly available from mining and other industry and governmental sources. Geomembrane/geotextile materials have been widely used in mining for well over 30 years, and are key components of virtually all hazardous and radioactive waste landfill designs in the US. In the latter application, detailed studies are normally required to predict facility performance over the long term. (p. 5)

Gregory A. Beischer (Doc. #4372.1)

- In section 4.3.2 the draft Assessment notes that if Pebble were "fully mined … may exceed 11 billion metric tons of ore…". The 11Bt noted by Ghaffari and used here by the EPA is the total resource – not the mineable, economic reserve. This seems to be an intentional inflammatory statement designed to alarm, and reveals the Authors unfamiliarity with the mining industry.
  I would further point out that if a public mining company were to report in a public document that it had 11 billion metric tons of ore, it would be subject to serious ramifications from stock exchange regulators. The EPA authors clearly do not have strong knowledge of the difference between a resource and a reserve. (p. 3)

Don Shepard (Doc. #4825.2)

- Unknown unknowns are not included. With examples in the assessment to multiple 100-year floods causing one failure, a magnitude 6.5 earthquake causing pipeline damage, and this area of Alaska receiving frequent earthquakes, consideration for such unknowns should be included. (p.1)
- Design goals are used for predictive analyses rather than data from historical experience. (p. 1)

Paula Riggert (Doc. #4845)

- Specifically, I'd like to call your attention to the seismic risks. Chapter 4 ("Mining Background and Scenario") discusses seismic risk. I am concerned that (as it states in Box 4-3) that the USGS data being used is from 1980. Methods of mapping of faults and other seismic assessments, records, etc. are more refined than 32 years ago. While it states in the report (p. 4-38) there is "a high degree of uncertainty in determining the location and extent of faults," this is not a strong enough warning about using data that is not current. In addition, even if the data is improved and brought up-to-date, the future will continue to bring a more refined understanding of the seismic risk. (p. 1)
- However, even with improved seismic risk data, the fact remains that the Bristol Bay watershed is an area with high seismic activity and risk. As discussed in Box 4-6 ("Selecting Earthquake Characteristics for Design Criteria"), mining companies use fault data and seismic risk assessments for developing such criteria as Maximum Credible Earthquake (MCE) and Maximum Design Earthquake (MDE) in designing facilities, including Tailings Storage Facilities (TSF). The MCE and MDE cannot be realistically determined, and the 2006 preliminary assessment by Northern Dynasty Minerals is not adequate. (p. 1)

D. Kohlmoos (Doc. #4848)

- Effects of vibration and sound on fry in rearing habitats along the pipeline and access road routes.
  - The influence of stress caused by the non-stop vibration and sound frequencies coming from activities associated with the pipelines and road warrants a more thorough investigation.
  - The influence of pipe break and spill on fry use of rearing habitat.
  - How many cubic feet of rearing habitat are lost just with the proposed pipeline and road routes?

- How much rearing habitat can this sustainable fishery afford to loose? What are the limits or justification for loss? (p. 1)

Stephen Gerdes (Doc. #4856)

- The transportation corridor from Cook Inlet to the mine site is anticipated to be 86 miles long and, once inland from Cook Inlet, would cross 34 spawning rivers and streams. How wide would this corridor be and how much additional surface area would be disturbed by the borrow pits needed for the construction of the corridor? What would be the total loss of wetlands and spawning streams because of the borrow pits and access roads leading to the pits? How would pipeline piers or supports be anchored and what effect would permafrost have on these structures and on any under ground sections of the pipelines? (p. 1)
- Underground seepage from tailings storage facilities and mine pits would apparently be captured, treated and returned to the existing drainages. Is there adequate understanding of the underlying geology so as to allow for realistic anticipation of underground water movement to provide for capture of contaminated water before mingling with surface waters or Lake Iliamna? (p. 1)

d. Potential Mine Failures

National Park Service (inclusive of USGS) (Doc. #4607)

- 4. Pages 4-38, second full paragraph, line 7: The report states, the USGS has concluded there is no evidence for movement on the Lake Clark Fault "in the past 1.8 million years." The USGS has never taken the position as stated in the report. The text in quotes should be replaced with "since the last glaciation around 11,000 to 13,000 years ago." (p. 6)
- 6. Pages 4-48, Box 4-6: From a geological and hazards perspective, the tailings dam should be designed to withstand shaking from the "Maximum Credible Earthquake" or MCE. The mine will be in operation a relatively short period of time, but the tailings dam will be there in perpetuity. If the regulatory desire is for contaminants to not escape the tailings dam, the seismic hazard will exist as long as the dam is in place. A related issue is that the MCE is established by consensus of knowledgeable scientists. This MCE is also subject to interpretation and it would be appropriate for the EPA to include the best earthquake scientists in this decision making process. A related topic is whether the EPA needs to have a concrete or legal definition of an active fault. In California, the legal definition is one that has been active or shows movement in the last 10,000 years. Although perhaps an arbitrary figure, in many regions of Alaska we can determine if a fault has moved since the last glaciation, which is slightly longer than 10,000 years. For this report, we suggest that an active fault be defined as, "one that has moved in either the last 10,000 years or since the last glacial maximum around 11,000 to13,000 years ago, whichever time frame is more practical to determine." (p. 7)
- 7. Page 4-48, Box 4-6, bottom paragraph: The ground accelerations listed during various magnitude earthquakes are likely global averages for earthquakes of a given magnitude; however, there are common examples of ground accelerations exceeding such values. For example, the relatively small 1994 Northridge earthquake in the Los Angeles area had a moment magnitude of 6.7, but ground accelerations measured 1.7g. Design criterion should

take into account the possibility of high ground accelerations that exceed average accelerations for a facility that needs to remain intact in perpetuity. In addition, the source of the listed ground accelerations should be cited. (p. 7)

- 8. Page 4-38, line 5, "length of the fault": The size of an earthquake is directly related to the area of the fault that ruptures not just the length of the fault. This should be clarified in the report. (p. 7)
- 9. Page 4-38, line 9 and following to the end of the paragraph: These are the largest strike slip fault systems in the region, but not all of them are known to be seismically active; it is implied that they are. The Border Ranges Fault, the Lake Clark fault, the Iditarod-Nixon Fork faults are not known to be active. This should be clarified in the report. (p. 7)
- 10. Page 4-38, paragraph 3: This discussion about the location of the Lake Clark fault is irrelevant if the Lake Clark fault is not active. Right now, there is no evidence for activity. Note, additional work could be done to assess if the fault is active, such as looking for the fault using airborne LIDAR, and looking for the fault beneath Lake Clark with multibeam bathymetry and seismic profiling. (p.7)
- 11. Page 4-39 last sentence: Geologic studies can also provide information on the rate of fault movement as well. Please include this in the list. It is important for seismic hazards as to whether faults are moving quickly or slowly. Also we suggest deleting "many" before "uncertainties" at the end of the sentence. (p. 8)
- 12. Page 4-43, Box 4-5, second to the last paragraph: This earthquake is known as the "Denali Fault earthquake," not the "Denali earthquake" as written. This should be corrected in the report. (p. 8)
- 13. Page 4-44, Table 4-7: The depth of these earthquakes, not just distance, is also very important. Depth should to be added to the table. We recommend the use of appropriate labels with the type of earthquake e.g. 1964 - megathrust earthquake; 2002 - Denali fault earthquake; 1985 - crustal earthquake or Benioff zone earthquake. (p. 8)
- 14. Page 4-44, last sentence: The term "overtopping" of what is not clear. It may be important as to the overall effect of earthquakes. This should be clarified in the report. (p. 8)

<u>Alaska Department of Natural Resources (Doc. #4818.2 and 4818.3)</u>

- In Chapter 4, the Assessment provides examples of catastrophic dam failures, and further describes failure mechanisms, such as overtopping and slope instability and then discusses failure statistics. However, the Assessment fails to point out that the failure statistics, as presented, do not distinguish catastrophic failures from relatively inconsequential incidents. This effectively exaggerates the probability of failure of the dam in the hypothetical mine scenario. (Doc. #4818.2 , p. 7)
- *Section 4.3, Page 4-6, Table 4-4*
  - *Comment:* To help place these data in context, the authors should add a column that shows the equivalent information for the hypothetical Pebble mine. Also, the table does not provide information on the local/regional geology or hydrogeology that would also help the comparison. (Doc. #4818.3, p. 31 to 32)
- *Section 4.3, Page 4-16*
  - *Comment:* In Table 4-4, EPA lists other mines and prospects in Alaska using Levit and Chambers, 2012 as the source. Fort Knox and Red Dog are the largest operating mines listed with tailings volumes of 200 and 100 million tonnes, respectively. The Donlin

prospect is also included at 472 million tonnes. No mines outside of Alaska are listed. The basis for the ore volumes is not mentioned.(Doc. #4818.3, p. 36)

- *Section 4.3.2, Page 4-17*
    - o *Comment:* EPA mentions two other mines outside of Alaska: "the largest porphyry copper mine in the United States (based on 2008 data) is the Safford Mine in Arizona, at 7.3 billion metric tons of ore [and] the largest in the world (based on 2008 data) is the Chuquicamata Mine in Chile, at 21.3 billion metric tons of ore." However, the source of the data is not clear. The 2011 annual report for Freeport-McMoRan Copper & Gold Inc. lists 206 million metric tons of ore at the Safford Mine. The basis for the discrepancy is not clear. EPA lists the potential mined ore at Pebble at 11 billion metric tons but fails to indicate the terms of these estimates (e.g. measured, indicated and inferred; proven and probable, etc.). (Doc. #4818.3, p.36)
- *Section 4.1.1, Page 4-17*
    - o *Comment:* While many of the hypothetical mine features may be transferable to other part of the region, the geologic and hydrogeologic conditions at the Pebble site area are likely to be unique. For example, the flow and seepage of groundwater into an 800 meter deep pit would very likely differ between site locations within the region due to different surficial soils and bedrock/aquifer permeability and connection with surface water bodies. This is a significant issue for the mine design.
    - o *Recommended Change*: Recommend revising this paragraph/sentence to acknowledge that the geologic and hydrogeologic conditions are not as readily transferable as other features. (Doc. #4818.3, p. 36)
- *Section 4.3, Page 4-17*
    - o *Comment:* The No Failure impact and effects scenario is likely overly conservative. Full containment and failure-free mining are not likely mine scenarios. Also, combining cumulative risks from the Failure scenario is not likely either. The risk analysis method used in the assessment describes the conceptual model framework identifying an envelope of potential risks, but does not quantify the risks to any degree of certainty. The risk assessment should seek to evaluate risks (and quantify where feasible) and identify the mostly likely mine development and failure scenarios to understand likely impacts, while stating the range of knowable risks.
    - o *Recommended Change:* Risk should be quantified, and estimated, where feasible (i.e. mine site footprint impacts, hydrologic impacts, dam failure) on elements of the study where this is feasible, and for items where calculation of risks and effects are unfeasible, scale of risk should be assigned (i.e. high probability and small area or low impact). A probabilistic risk based analysis of a likely mine operation and failure scenario would reduce uncertainties leading to underestimates and overestimates of stated risks and impacts. (Doc. #4818.3, p. 37)
- Section 4.3.2, Page 4-17 and 4-19
    - o *Comment:* On page 4-17, the report states that "If fully mined, the Pebble deposit may exceed 11 billion metric tons of ore…" On page 4-19, the report states that "In our mine scenario, we have defined a minimum and a maximum mine size of 2 billion metric tons and 6.5 billion metric tons of ore, respectively."
    - o *Recommended Change:* Include justification for why the 6.5 billion metric tons of ore scenario is the "most likely" mine size versus the estimated maximum potential of 11 billion metric tons of ore. (Doc. #4818.3, p.37)

- *Section 2.2.3, Page 4-20, Figure 4-7*
  - *Comment*: Whereas the maximum mine size figure appears to show a dam for the TSF1, there is no indication of the dam location for TSF2 or TSF3.
  - *Recommended Change:* Recommend adding the dams to this figure. (Doc. #4818.3, p. 37)
- *Section 4.3.5, Page 4-21*
  - *Comment:* The dam size, location and retaining volume are estimated and described, but there is no discussion as to how the quantities were estimated. (Doc. #4818.3, p. 38)
- *Section 4.3.5, page 4-21*
  - *Comment:* In the first sentence in the first paragraph, the report discusses a 2006 water right application submitted by Northern Dynasty Mine. These quantities should be compared to the volumes/rates discussed later in the water balance part of Section 4. (Doc. #4818.3, p. 38)
- *Section 4, Page 4-21*
  - *Comment:* The following comment is an example of how possible mitigation methods could reduce the level of environmental concern and significantly alter the conclusions of impact if the mine plan used in the assessment had been vetted through the environmental and permitting review processes.

    The narrative is identical to the narrative in the Northern Dynasty Minerals, Ltd report with regard to the percent of pyritic tailings versus bulk tailings. The Northern Dynasty Minerals, Ltd. report defines these tailings as inert or non-acid producing. They are the rougher tails from the first flotation circuit. The Bristol Bay Watershed Assessment says that the pyritic tailings would be discharged below the water surface of the tailings pond and encapsulated in NAG tailings to retard the rate of pyrite oxidation. Given the fact that nearly 1 billion tons of pyritic tailings would be produced for the full mine, it is important to evaluate in greater detail the potential for this material to oxidize. Variables that are not immediately clear are a) what will be the percolation rate of water through the tails?; b) there is approximately 65 feet of gravel in many areas of the TSFs and they will not be lined. What will be done to prevent seepage in these gravels?; c) how will the TSF dams be constructed to greatly reduce seepage under the dam?; d) how will rainwater and snowmelt (which is relatively high in dissolved oxygen), affect the oxidation rate?; and e) how will normal seepage through the dam affect water movement and hence oxidation, through the pyritic tails?
  - *Recommended Change:* Get more detailed information on this topic and include it in Section 4.3.5 of the Bristol Bay Watershed Assessment. (Doc. #4818.3, p. 38)
- *Section 4.3.6, Page 4-23*
  - *Comment:* In Section 4.3.6, waste rock disposal areas are described without a specific description of the basis for the estimated size or footprint, apart from stating "these piles will be constructed with a geometry designed to reduce the amount of runoff requiring treatment." (Doc. #4818.3, p. 39)
- *Section 4.3.5, Page 4-23*
  - *Comment:* The second paragraph discusses a well field to monitor groundwater flowing down the valley. However, no specific details are provided for these wells.
  - *Recommended Change:* Recommend including estimates of the number of wells that might be needed to monitor groundwater quality and intercept seepage, well depths,

spacings, diameters, construction materials and possible drilling challenges based on the local hydrogeology. Also recommend discussing the well maintenance program options that would ensure the wells are kept operational. (Doc. #4818.3, p. 39)

- *Section 4.3.6, Page 4-25, Figure 4-9*
  - *Comment*: This schematic figure gives a misleading sense of the depth of the open pit relative to the groundwater conditions (as they appear to be understood). Although this figure is not to scale, if the intended pit depth is 800 meters, the base of the pit should be far deeper than shown. Also, one would expect a local groundwater mound to develop beneath the Waste Rock area in the lower figure (Post-Closure), with groundwater moving towards the pit and the stream.
  - *Recommended Change:* Revise the figure to better reflect the pit depth and groundwater flow pattern. (Doc. #4818.3, p. 39)
- *Section 4.3.6, Page 4-25, Figure 4-9*
  - *Comment:* The figure shows a simplified schematic of the dewatering and water management system at the mine. What are the potential groundwater seepage and contaminant pathways? Pathways that come to mind are the shallow groundwater seepage through the bottom (unlined) portions of the TSF and fracture zones in the weathered bedrock layers.
  - *Recommended Change:* Recommend adding geology and soils information regarding the glacial deposits, with underlying weathered and competent bed-rock to the figure and discussion. Identify potential contaminant pathways on the schematic which should be consistent with the conceptual modeling schematics in Section 3. (Doc. #4818.3, p. 39)
- *Section 4.3.7, Page 4-26*
  - *Comment:* The river diversion plan assumes that the blocked creeks/rivers will eventually find a way to flow around the mine site and TSF, however, it might not be the case in many areas, particularly during the high flow season (either caused by heavy rainfall and snow melt). During the high flow season, surface water runoff might cause flooding, top the TSF, and/or move the potential contaminants into downstream water bodies if PAG waste rock is encountered.
  - *Recommended Change:* Provide more detailed info on the river diversion plan, including the topographic information for the areas where the streams will be blocked by the mine pit or waste rock piles. Provide high seasonal flow information in the affected area and its impact on the mine site and safety of the TSF dam. (Doc. #4818.3, p.39 to 40)
- *Section 4.3.7, Page 4-26*
  - *Comment:* The document points out impacts that would "reduce or eliminate stream flows". While these statements may be correctly applied to the local streams near the potential mine site, the impact to the larger stream systems is negligible, especially to the Bristol Bay Watershed. The document fails to put this in proper perspective.
  - *Recommended Change:* The document should demonstrate the potential impact to a larger stream system and overall potential impact to the Bristol Bay Watershed. (Doc. #4818.3, p. 40)
- *Section 4.3.7, Page 4-27, Box 4-2*
  - *Comment:* The report notes (Box 4-2) that a range of hydraulic conductivities have been measured in the area. However, the seepage calculation assumes a single value for each of the upper 200 meters and deeper materials. This range is not provided to enable the

reader to put the selected values into context. Also, the selection of a relatively low hydraulic conductivity (10-8 m/s) for the deeper materials should be discussed in terms of primary or secondary porosity, and the likelihood that a mine of such dimensions would encounter water-bearing fracture zones and what the inflow contribution might be.
    - *Recommended Change:* Revise the seepage calculations and discussions to include a range of hydraulic conductivity values and the potential for water-bearing fracture flow contributions. (Doc. #4818.3, p.40)
- *Chapter 4, Page 4-27*
    - *Comment:* This page states that the mining operation would always consume some water and there would always be less water available in streams during active mining than there was before the mine was present. This contradicts Section 5.3.1 which states that "During the start-up phase, all water from the site would be collected and used in operations. However, during the minimum and maximum mine operations, 5 million to 48 million cubic meters of water available on the site per annum would exceed operational needs, and treated water would be discharged. (Section 4.3.7)". This contradiction is important to rectify since it has implications to the health of the streams and fisheries below the mine.
    - *Recommended Change:* Evaluate this item in detail and provide narrative on it. Make any changes to the water balance. (Doc. #4818.3, p.40)
- *Section 4.3.7, Page 4-27*
    - *Comment:* The report assumes that the mine would be located on a water divide; therefore, there will be little groundwater contribution into the area defined by the cone of depression. This assumption is not well supported due to two reasons: 1. The surface water divide does not necessarily match the groundwater divide. Regional groundwater flow is not presented in the report to determine the location of groundwater divide. 2. Dewatering and mining activities in the mine site will change the local, and possibly the regional, groundwater flow field, which will change the water balance.
    - *Recommended Change:* Provide regional hydrogeological information such as cross-sections, logs, lithologies, groundwater levels, and groundwater contour maps. (Doc. #4818.3, p. 40 to 41)
- *Section 4.3.7, Page 4-27 and 4-28*
    - *Comment*: The water budget section of the report indicates how the estimation of water budgets was conducted by stating "Developing a water balance for these stages is important to the assessment, because it determines the amount of water available at the site that could still contribute to downstream flows (Box 4-2). However, water balance development is challenging and requires a number of assumptions. It depends upon the amount of water needed to support mining operations, the amount of water delivered to the site via precipitation, the amount of water lost due to evapotranspiration, and the net balance of water to and from groundwater sources. Information exists to estimate precipitation and evapotranspiration, and estimates of water needed for mining operations are available based on typical mining practices (Ghaffari et al. 2011). More challenging, and potentially the largest source of uncertainty, is determining the net balance of water from groundwater sources.". The water budget estimating methods described in Box 4-2 do not specify the type of calculation or model used to evaluate the water budget. It is assumed that a deterministic, spreadsheet, model was used to grossly estimate the mine water budgets for the various mine development and closure phases.

- *Recommended Change:* Provide an expanded discussion of the type of water budget model used, assumptions made, data sources, uncertainties and limitations in modeling estimates. The use and application of a more robust modeling system that can integrate surface and groundwater hydrology and mining industrial water operations is needed to more accurately represent water management and water budget conditions. (Doc. #4818.3, p. 41)

- *Chapter 4, Page 4-28*
  - *Comment:* This page describes the water balance calculations expected for the mine. The mine inflow assumptions seem reasonable and are calculated to be 1.06 cubic meters per second for the maximum mine. However, this number has such an important bearing on the overall water balance that it must be checked in detail. If the number is actually much lower, then the mine may not discharge during the mine life, since considerable water will be consumed in the tailings deposition. This could affect fish habitat for some distance downstream. If it is much higher, the flows in the streams could be increased downstream of the mine, resulting in increased erosion of the banks for some distance downstream.
  - *Recommended Change:* Use a seasoned ground water expert with experience in evaluating mine inflows from large pits to provide a full evaluation of the mine inflow predictions. Make any changes to the water balance, if necessary. (Doc. #4818.3, p. 41 to 42)
- *Chapter 4, Page 4-28, Box 4-2*
  - *Comment*: The report assumes that groundwater is limited to the top 100 meters, only. Is there any evidence that a deeper aquifer does not exist at the mine site? As stated in Table 4-3, page 4-15, the mine pit will extend to 800 meters and 1,200 meters for the minimum and maximum mine, respectively. The potential to encounter a deeper aquifer under the mine will change the water balance significantly due to potential for a large amount of water from fracture flows in the deeper portion of the mine pit.
  - *Recommended Change:* A detailed hydrogeological description in the mining area is needed to determine if a deeper aquifer(s) exists to a depth of 1,200 meters. (Doc. #4818.3, p. 42)
- *Section 4.3.7, Page 4-28*
  - *Comment:* Box 4-2. Water Balance Calculations: The fundamental definition of a water balance is not adhered to in the discussion, thus making the results of the analysis worthless. Although the authors purportedly seem to be able to design AND comment on the negative effects of a yet to be designed and permitted facility, the water balance cannot be finalized until an understanding of water use within the facility itself is complete. The hypothetical inflows and outflows of a speculative design do not in itself, constitute a water balance. (Doc. #4818.3, p. 42)
- *Section 4.3.7, Page 4-30, table 4-5*
  - *Comment:* The geographical basis for the water balance provided in Table 4-5 excludes the area outside the immediate vicinity of the mine site. Typically, project-area water balances take into account flows for individual surface water bodies, water-bearing units/aquifers, and areal variability of precipitation and runoff components. In short, this water balance appears to lack acknowledgement of the key natural systems at and near the mine site. Also, water balances consider seasonality aspects (for example, monthly) and the effect of wetter- and drier-than-average years.

- *Recommended Change:* The water balance should be fully reconsidered taking into account the comments above, and represented in a concise way with supporting figures, charts and tables. (Doc. #4818.3, p. 42)

- *Section 4, Page 4-30, Table 4-5*
  - *Comment:* Table 4-5 indicates that water captured at the mine site is the same for the maximum mine condition and for the Post-Closure condition (both 41.2E6 cubic meter/year). The amount of water captured should not be the same under these two conditions due to the change in groundwater/surface water interaction. As mining progresses, the mine pit has the potential to intersect more groundwater from fracture flow. After the mine is closed, as the water level increases in the mine pit, less groundwater could flow into the mine.
  - *Recommended Change:* Provide explanation for the same amount of water being captured for the maximum mine and post-closure conditions. (Doc. #4818.3, p.42 to 43)
- *Section 4, Page 4-30, Table 4-5*
  - *Comment:* Table 4-5 indicates that the "stored in TSFs as pore water" for the Start-up condition is 25.5E6 m3/year. The amount of the water as shown in the table indicates the same amount of water "stored in TSFs as pore water" for each year for minimum mine operation period. There should be a minimum amount of material in TSFs, if any, during the Start-Up phase. (Doc. #4818.3, p. 43)
- *Section 4, Page 4-30*
  - *Comment:* This page summarizes the water balance calculations expected for the mine. Although the water that will be captured by blocked streams is not actually part of the mine, it is an important part of the water balance and therefore, should be addressed. It is understood that diversions will be placed in the blocked drainages to divert what amount is feasible downstream through diversions, but there is no discussion of what blocked stream segment water will be backed up against the embankments that cannot be conveyed through diversions due to elevation. Pass through pipes underneath the TSFs will probably not work in perpetuity.
  - *Recommended Change:* Evaluate this item in detail and provide narrative on it. Make any changes to the water balance, if necessary. (Doc. #4818.3, p. 43)
- *Section 4, Page 4-30*
  - *Comment:* Using retention of 30% water by weight, calculations of the amount of pore water that will remain in the tailings each year after settlement and recapture of clean water using the floating barge in the TSFs can be estimated. The amount of 26.5 million cubic meters per year shown in the Table is reasonable. The post-closure column (Table 4-5) also correctly shows that no new water will be stored in the TSFs as pore water. What is not mentioned is that approximately 735 million cubic meters of permanent water will remain in the tailings as pore water over the life of the mine that will not be recaptured by the floating barge. This water would primarily come from precipitation and water inflow from the mine pit. This may be acceptable over 78 years time, but it is an extremely large amount of water that will essentially be taken from groundwater (in the mine pit) and placed in the TSFs. This should be discussed in the water balance. A more detailed evaluation of the water balance is needed.
  - *Recommended Change:* Describe the consumptive use of the pore water in the tailings over the life of the mine and its possible effects downstream on the groundwater and surface water systems. (Doc. #4818.3, p. 43)

- *Section 4.3.8, Page 4-31*
    - *Comment:* The document states an assumption that the mine would close " when all currently identified economically profitable ore is removed" . PLP has not demonstrated that there is any "economically profitable ore" at this time. Final feasibility studies, mine plans and numerous other studies would have to be complete before PLP could report a reserve or "profitable ore".
    - *Recommended Change:* Drop "currently identified" from the text (Doc. #4818.3, p.44)
- *Section 4.3.8.3, Page 4-31*
    - *Comment:* The document (p. 4-32) uses an assumption that a stable angle for waste rock slopes would be less than 15 %. There is no basis for this and our experience has shown that most reclaimed waste rock dumps are stable at 33 % and depending on the material, may be stable at steeper slopes. A steeper slope could reduce the overall footprint.
    - *Recommended Change:* Eliminate the 15 % reference. (Doc. #4818.3, p. 44)
- *Section 4.3.8.5, Page 4-33*
    - *Comment:* Premature mine closure is discussed (p. 4-33). There are two sentences that need additional discussion. First "In one study of international mine closures between 1981 and 2009, 75% of the mines considered were closed before the mine plan was fully implemented (Laurence 2011)." Second, later in the section states "Because premature closure is an unanticipated event, water treatment systems would likely be insufficient to treat the excessive and persistent volume of low pH water containing high metal concentrations." If the premise of a high rate of premature closure is true as presented in the assessment, it would be reasonable for the authors to assume premature closure as a likely scenario and the study should include this consideration in the No-Fail scenario or likely scenario analyses.
    - *Recommended Change:* Include an expanded discussion of premature closure, the uncertainty, and the potential impacts on fisheries and indigenous cultures as this condition is likely to occur. (Doc. #4818.3, p. 44 to 45)
- *Section 4. Page 4-33 and 4-39*
    - *Comment:* Page 4-33 states that the water from the leachate collection systems would be treated until necessary. Page 4-39 discusses water collection and treatment failure but focuses on a prediction of seepage flows through the TSFs, which would be untreated. This section goes on to state that if a treatment failure occurs, the expected discharge rate is 0.00115 m3/sec. This is not a large flow and it is probably not the biggest risk with this type of failure. If a large treatment plant is in place, it may be possible that a large surge of untreated water would be discharged and this is not addressed in detail. The extreme weather conditions of this site combined with the fact that water treatment would go on for a very long time after closure, point to a significant possibility of "incidents" with the water treatment system which could produce much larger quantities than the expected seepage, albeit for a short time. Nevertheless, a surge like this could have a significant impact downstream. The treatment plant designs must have significant backup systems and safety factors to account for these possibilities.
    - *Recommended Change:* Describe the potential impacts of temporary failures of the water treatment system and the effects of possible surges of poor quality water on the downstream fish habitat. (Doc. #4818.3, p. 45)
- *Section 4, Page 4-35 and Appendix G*

  - *Comment:* These pages show the road and pipeline corridor on maps. The maps fail to point out that a portion of the road is already built, which is from Williamsport to Pile Bay, as shown on Figure 18.2.5 of the Northern Dynasty Minerals, Ltd. Report of 2011. Another smaller section near Pedro Bay is also in place.
  - *Recommended Change:* Revise these pages and maps to show those sections of road that are already built and describe the widths and stream crossings that are in place and may need upgrading. (Doc. #4818.3, p. 45)
- *Section 4.4.1, Page 4-39*
  - *Comment:* In the first paragraph, the report discusses failure of the collection and treatment facility, and assumes a hydraulic conductivity for the permeable substrate for the upper 30 meters by using a value from the Pebble Limited Partnership's 2011 report. This value is two orders of magnitude lower than the value used in the mine pit seepage calculation (Box 4-2) despite representing a shallower layer of material that one would expect to have a similar (or even higher) hydraulic conductivity.
  - *Recommended Change:* The report should provide some clarification regarding the selected parameter value, and even consider providing flows based on a range of values given the apparent uncertainty regarding the actual site location and specific hydrogeologic conditions. (Doc. #4818.3, p. 45 to 46)
- *Section 4.4.2, Page 4-39*
  - *Comment:* EPA states, "A tailings dam failures occurs when a tailings dam loses its structural integrity and releases tailings material from the impoundment. The released tailings flow under the force of gravity as a fast-moving flood containing a dense mixture of solids and liquids, often with catastrophic results." EPA lists examples of such catastrophic failures in Box 4-4. EPA then describes failure mechanisms such as overtopping and slope instability and then discusses failure statistics. However, EPA fails to point out that the failure statistics as presented do not distinguish catastrophic failures from relatively inconsequential incidents, thus implying that the failure probabilities are applicable to the uncontrolled release of tailings or otherwise catastrophic failures. (Doc. #4818.3, p. 46)
- *Section 4.4.2, Page 4-40*
  - *Comment:* EPA implies that because the tailings dam heights used in the mine scenario are very large, the impacts of a failure would be much greater than the historical failure record from much smaller dam failures. Box 4-4 lists four examples of tailings dam failures, including the 2008 flash pond failure at the Kingston Power Plant in Tennessee. All of the dams described are less than 30 meters high, and all have questionable design and operational histories. EPA fails to acknowledge that tailings dam failure statistics are biased by the failure incidents of such small dams, because there have been no catastrophic failure of large dams approaching the scale of the mine scenarios used in the Assessment. (Doc. #4818.3, p. 46)
- *Section 4.4.2.1, Page 4-40*
  - *Comment:* EPA describes causes of tailings dams failure such as overtopping, slope instability, earthquakes and foundation failures. However, such failures are highly dependent on a number of site and project specific factors such as available construction materials, foundation type, (bedrock vs. depositional soil) and hydrology and hydraulics design.(Doc. #4818.3, p. 46)
- *Section 4.4.2.1, Page 4-44*

- *Comment:* The Assessment indicates that overtopping is one of the leading causes of inactive tailings dam failures. However, this data is biased because the sample population includes a number of failures of dams with inadequate spillway designs. Any large or very large tailings dam in Alaska must be designed to accommodate the Probable Maximum Flood (PMF) during operations, and safely pass the PMF through a properly designed spillway in closure. Note that the PMF is a misnomer, in that there is no specific probability associated with the event since it represents the result of the most severe meteorological and hydrologic event that is reasonably possible at a given site. The argument that a large or very large tailings dam built in Alaska would be particularly susceptible to failure due to overtopping based on historical evidence of international tailings dam failure incidents is systematically flawed. (Doc. #4818.3, p. 46 to 47)

- *Section 4.4.2.1, Page 4-44*
  - *Comment:* In Table 4-7, EPA lists examples of earthquakes in Alaska ranging from a magnitude 3.0, located 122 km from the project, to the Great Alaska Earthquake of 1964, a magnitude 9.2 located 469 km from the project. The nearest earthquake listed is a magnitude 4.3, located 30km from the project. A note on the table states, "…earthquakes in the range of magnitudes 2.5 to 3.6 occur regularly in the Lake Clark area…)". The earthquakes listed by EPA in relation to the Pebble deposit are technically insignificant. National guidelines for incident reporting for dams do not require reporting for earthquakes less than 5.0 within 24 km of the project site, or for earthquakes greater than 8.5 more than 102 km from the site. (Doc. #4818.3, p. 47)
- *Section 4.4.2.2, Page 4-45*
  - *Comment:* EPA references Chambers and Higman (2011) for tailings dam failure statistics (p. 4-45). Reviewers question the use of this reference as it is a literature summary drawing conclusions that do not appear to have been peer reviewed and is written by a non-profit advocacy organization. See: http://www.csp2.org/reports/Long%20Term%20Risks%20of%20Tailings%20Dam%20Failure%20-%20Chambers%20&%20Higman%20Oct11.pdf (Doc. #4818.3, p. 47)
- *Section 4.4.2.2, Page 4-45*
  - *Comment:* EPA states, "Low failure frequencies and incomplete datasets also make any meaningful correlations between the probability of failure and dam height or other characteristics questionable. Very few existing rockfill dams approach the size of the structures in our mine scenario, and none of these large dams have failed." Nevertheless, EPA continues in their conjecture to presume that the tailings dam fail during both the operation and post-closure phases of the mine. (Doc. #4818.3, p. 47)
- *Section 4.4.2.2, Page 4-45*
  - *Comment:* The EPA presents statistics on dam failures and gives an upper bound of one failure per approximately 2,000 mine years. However, the EPA fails to describe whether the respective failures had any adverse impact on the environment. For example, a slope stability type dam failure may be reported, but not necessarily have resulted in any adverse impact on the environment downstream of the dam. (Doc. #4818.3, p. 47 to 48)
- *Section 4.4.2.2, Page 4-46*
  - *Comment:* EPA states, "This analysis considers the effects of earthquakes based on a site-specific evaluation of seismicity in the area. Box 4-6 describes the selection of earthquake characteristics for design criteria." In fact, Box 4-6 describes earthquake

design criteria in general terms such as the Operating Basis Earthquake (OBE) and the Maximum Design Earthquake (MDE), but cites Northern Dynasty for specific, proposed ground motions (NDM, 2006). This reference is not included in Chapter 9, Cited References. While Figure 4-11 shows a seismic activity map for southwestern Alaska, EPA has not conducted a presented a technically defensible, probabilistic or deterministic seismic study for the region. (Doc. #4818.3, p. 48)

- *Section 4.4.2.2, Page 4-46*
  - *Comment:* EPA cites ADNR Guidelines for Cooperation with the Alaska Dam Safety Program (June, 2005) (ADNR Dam Safety Guidelines) and references therein to U.S. Army Corps of Engineers, U.S. Bureau of Reclamation, and Federal Energy Regulatory Commission guidelines for designing water retaining dams to safety factors of 1.5 (for slope stability). Box 4-6, Selecting Earthquake Characteristics for Design Criteria, includes general descriptions of earthquake design criteria, and criticizes the ADNR dam safety guidelines as 'inconsistent with the expected conditions for a large porphyry copper mine developed in the Bristol Bay…" Section 13.2.2, Tailings Storage Facilities, of the ADNR Dam Safety Guidelines specifically states, "Complete guidance on tailings dam design and closure is beyond the scope of this document…tailings dams represents certain challenges that require professionals with significant relevant experience." EPA leans heavily on the 1.5 safety factor for estimating failure probabilities and references (Silva, et al. 2008). However, unlike the Assessment, Silva presents a balanced discussion on risk for a mine project, and other engineering features such as dams. (Doc. #4818.3, p. 48)
- *Section 4.4.2.2, Page 4-47*
  - *Comment:* EPA uses curves from Figure 1 of Silva et al, 2008 to convert the factor of safety associated with the mine scenario tailings dam to an annual probability of failure (p. 4-47). The scope of Silva's paper is broad and is intended for a wide range of potential geotechnical applications. The four categories of "Level of engineering" included in the Assessment are abbreviations of the more detailed Table 1 included in the referenced paper. A review of Table 1 indicates that the Class II (Above Average) category is reserved for "above average" geotechnical works in a general sense. For example, Class II structures do not require an investigation of site geologic history, design peer review, full time supervision by a qualified engineer during construction or implementation of a performance program during operation, all of which would be required of any new tailings dam constructed in Alaska. The EPA assumes that the mine scenario tailings dam will be between a Class II and Class I structure and chooses to use the annual probability of failure associated with Class II structures (10-4 with a FOS of 1.5) for comparison with high historical tailings dam failure rates. Based on Silva's definition, a new large or very large tailings dam constructed in Alaska would almost certainly fall into category 1 (Best). The corresponding annual probability of failure of a Class I structure with a FOS of 1.5 is 10-6. (Doc. #4818.3, p. 48 to 49)
- *Section 4.4.2.2, Page 4-47*
  - *Comment:* The likelihood has been estimated, substantially, from the historic records of dam failures that have been recorded in the years 1960 to 2010. Many of the dams that are included in this failure record were constructed in periods prior to current engineering and oversight. The ability to perform effective analyses must precede the practice of performing such analyses and if we look to when a) the capability and b) the practice of

analyses of very important aspects of dam design were developed, we can see that many dams that have failed were not designed with adequate design methods. The flowing times are when the technology and practice became common for critical elements of tailings dam design in North America:

- Slope stability analyses 1960's
- Seepage and drainage analyses 1970's
- Seismicity, foundation soils and tailings liquefaction, and dynamic analyses 1970's and 80's
- Modeling tools for deformation (FLAC, PLAXIS) Post 1980's
- Design for Closure and Closure management (not just abandonment) has only been a substantive requirement since the 1990's.

In areas other than North America, these technologies and the regulatory oversight and corporate governance that today control the security of dam construction were not applied till substantially later.

Thus many of the dams, indeed the vast majority, included in the failure statistics did not include the design, specifications and construction and operation supervision that would be required today for a major tailings dam constructed in Bristol Bay.

The site investigation, construction material characterization, design effort and construction supervision that is applied to smaller, lower hazard dams are vastly less than are applied to very large high hazard dams. The engineering man-hours that would be devoted to the investigation, design and construction supervision for the 'very large dam' that has been assumed for the MS would be many times (orders of magnitude) greater than that applied to the smaller dams of several decades ago.

The likelihood of failure of a large dam constructed with the current technology, regulatory control and corporate governance, that would be applicable at Bristol Bay, would be grossly overestimated by the likelihood ranges derived from historic failures. (Doc. #4818.3, p. 49)

- *Section 4.4.2.2, Page 4-47*
  - *Comment:* Dam failure probabilities based on existing and anecdotal information shows a wide range (several orders of magnitude) difference in probability of failure.
  - *Recommended Change:* Considering the potential risks involved, the dam failure study should include a site specific dam failure analysis. A stochastic, risk based modeling approach is needed to address risk and uncertainty and incorporating sensitivity analyses of seismicity, soil strength and hydraulic conductivity properties, inflow hydrology, dam breach sizes, hydraulic and sediment transport downstream modeling. The analysis will refine probabilities and estimates of dam failure scenarios and reduce the uncertainty in dam failure orders of magnitude difference in estimated failure probabilities. (Doc. #4818.3, p. 50)
- *Section 4.4.2.2, Page 4-47*
  - *Comment:* Hydraulic modeling of downstream areas from dam failure and overtopping was performed as described in Box 4-8. The approach analyzes a probable maximum flood (PMF) inflow using Hydrologic Engineering Center's (HEC) -1for hydrologic modeling. Downstream rivers and streams were modeled using HEC-River Analysis System (HEC-RAS). The methods section does not describe specifically how dam breach size estimates were determined, and how the downstream sediment transport analyses were performed.

- *Recommended Change:* The report should include information about what methods were used to analyze the dam breach size and flow conditions, and the associated sediment transport analyses. Empirical methods applied should be specified, such as those outlined in Prediction of Dam Breach Parameters, USBR 1998, and/or use of dam-break software to estimate breach sizes. This is important as the breach size; reservoir and tailings stages will highly influence the flood hydrograph. The sediment transport data collection and modeling work should be expanded in support of the study (both spatially and identifying / specifying the type of model being used). If not already being used, a mobile bed sediment transport and sediment routing model will likely be necessary to understand dam breach, sediment transport conditions and spatial extents of tailings deposition extents to any degree of certainty. Once the sediment deposition areas have been established, then downstream water quality impact assessments could be updated and refined. Dam break sedimentation impact areas could also be directly overlaid with existing fish habitat areas using GIS. The use of this type of model was likely beyond the scope and means of the initial assessment. However, it will be important to understand, characterize and quantify impacts (sediment and water quality), as well as to communicate risks and impacts to a broad audience regarding the potential catastrophic impacts to fisheries resources from a tailings dam break scenario. (Doc. #4818.3, p. 50)

- *Section 4.4.2.2, Page 4-48*
  - *Comment:* In Box 4-6, EPA suggests that an earthquake return period of 2500 years may be too short for a tailings dam that could have a life expectancy of 10,000 years after operations cease. The design earthquakes that Northern Dynasty proposed seems reasonable, based on the information presented, but the accelerations used for design must be coupled with details for the structures setting. For earthquakes return periods greater than 2500 years, the design earthquake can be set so high that, should it occur, rivers and streams may be naturally destroyed while the dam itself would be unaffected. (Doc. #4818.3, p. 50 to 51)
- *Section 4, Page 4-48*
  - *Comment:* This page states that the maximum credible earthquake (MCE) of 7.8 was used to determine a maximum ground acceleration of 0.44g to 0.48g, which was used in the stability calculations of the dam. The Knight Piesold Report in 2006 titled "Pebble Project Tailings Impoundment A – Initial Application Report" shows an MCE of 7.8 producing a maximum bedrock acceleration of 0.30.
  - *Recommended Change:* Correct or explain the rationale for the discrepancy. (Doc. #4818.3, p. 51)
- *Section 4.4.4, Page 4-63*
  - *Comment:* The narrative does not recognize BMP of culvert designs, particularly in anadromous stream crossings. Besides the discussion regarding bridges versus culvert crossings, any culvert crossing would be designed to accommodate fish passage except at times of extreme flooding when fish passage through ordinary stream channels may be impeded as well. The evolution of culvert design has greatly advanced in the last 20 years or more. (Doc. #4818.3, p. 51)

<u>Bristol Bay Native Corporation (Doc. #4382.2)</u>

- The Draft Assessment does not squarely address the challenges of constructing and operating a modern day mine that could actually meet the "no failure" scenario with respect to reclamation.10 Post-closure, aquatic habitats would have to be recreated on an unprecedented scale and waters within the reclamation area would have to meet water quality standards. The Draft Assessment leaves unanswered a number of questions about the feasibility of reclamation, including whether there will be adequate cover material and topsoil, and whether any mining project in a sub-arctic region has ever successfully achieved reclamation of this nature on so large a scale. We recommend that EPA address these questions in the Final Assessment. (p. 4)

The Pebble Limited Partnership (Doc. #3797.2, 4960, 4962, and 5416)

- Projected Culvert Failures. The peer reviewers should be asked to analyze the support for EPA's estimated culvert failure rate, and whether EPA adequately considered long term operation and maintenance activities associated with an active mining operation and post-operational use of the transportation corridor. The peer reviewers should be asked whether EPA adequately considered all viable engineering options (such as bridges) in estimating a large failure and blockage rate associated with the transportation corridor. (Doc. #3797.2, p. 3)
- Last, the Assessment's hypothetical failure and post-closure scenarios do not show that adverse effects "will" occur as the result of mining at the Pebble site. To illustrate, the Assessment is unable to determine any realistic probability of a tailings dam failure, instead concluding that one might be expected to occur once every 10,000 to 1 million mine years. 61 The Assessment goes on to observe that "[a]ctual failure rates could be higher or lower than the estimated probability. In other words, EPA has little idea what the probability is of such a failure. This is but one of the many examples where EPA references potential impacts, but the information used does not support an opinion on the probability or even extent of those potential impacts. Thus none of the failure scenarios or long-term contingencies contemplated by the Assessment justify the exercise of EPA's Section 404(c) authority. (Doc. #4960, p. 18)
- **Pipelines.** The pipeline failure rates used in the assessment are based on aggregated information from several countries spanning a wide range of construction techniques and pipe sizes. It is not clear what design standards those pipelines were constructed to. The estimate of expected pipe failure rate in the hypothetical mining scenario should be based on failure rates of pipelines of similar size and modern construction designs (e.g. anticorrosion/erosion inner HDPE lining, a surrounding steel pipe, insulation) that would be built and maintained to U.S. standards. (Doc. #4962, p. 5)
- **EPA relies on tailings facilities built in the late 1800s and modern engineering that would have prevented these historical dam failures was ignored**. The Assessment presents a mine scenario and assumptions that fail to meet the standards for mine development and environmental assessment in the State of Alaska and the United States of America. The Assessment Report includes a flawed risk assessment that draws false conclusions based on past examples from other jurisdictions and mining practices that are not permitted in the State of Alaska. The Assessment Report states that "the assessment largely analyzes a mine scenario that reflects the expected characteristics of mining operations at the Pebble deposit". In fact, the EPA grossly underestimates the high standard to which a mine in the Bristol Bay watershed would have to be designed and engineered in order to obtain permits to operate in the watershed. It also underestimates the role of various federal and state regulatory agencies in the permitting process that will help ensure that a technically

advanced mine would be designed and operated. (Doc. #4962, p. 7)

- **EPA's statistics overstate the chances of a tailings dam failure today.** The Assessment has misrepresented the likelihood of tailings dam failure for any proposed mining development in Alaska. The International Commission on Large Dams (ICOLD) tailings dam failure statistics are extensively referenced in the Assessment Report, either directly or indirectly through selectively citing other technical articles. However, these ICOLD statistics do not support the premise that tailings dam failure is a reasonable hypothesis for a modern mine operation in the Bristol Bay watershed. The ICOLD document provides some summary statistics on the frequency of tailings dam failures and states the following; "In highlighting accidents, the aim is to learn from them, not to condemn". Conversely, the Assessment incorrectly implies that generalized statistics for worldwide tailings dam failures can be applied to individual tailings dams to suggest a high potential for failure over an extended period of time. This premise is erroneous and misleading, as it is incorrect to imply that any particular proposed or actual dam structure is more or less likely to fail based solely on extrapolation of general dam failure statistics based on dissimilar dams. (Doc. #4962, p. 7-8)
- **The Dam Breach Model is flooded with bad assumptions and with uncertainty, so EPA's estimate of the environmental impacts of (an unlikely) dam failure is drowning in bad science.** The Assessment includes a questionable dam breach assessment where the high uncertainty associated with the peak flow estimate and modeling predictions is not presented, and where the relative magnitude of the dam breach flood is wrong. In an effort to illustrate the extreme magnitude of the dam breach flood, it was compared to a natural flood in the region, but errors were made in the calculations and the comparison was done in a manner that exaggerates the result. The errors were in the drainage areas stated for both the dam breach flood and the regional flood, and appear to stem from an inability to convert from imperial units to metric units (sq. miles to equivalent sq. kilometers). The lack of rigor used in these analyses results in misleading statements concerning the potential impacts of mining development in Bristol Bay. (Doc. #4962, p. 8)
- **EPA's conclusions are based on outdated information.** The Assessment presents a general assessment of roads and culverts that implies that the installation of culverts (which represent a large fraction of typical stream crossings) "may" or "could impose a negative impact on the physical and biological resources of streams and wetlands within the Bristol Bay study area. The Assessment supports this conclusion with outdated references and information that assess the potential impacts of proposed stream crossings on deficiencies of existing structures that may have been designed using obsolete methodologies, are improperly maintained, or both. In the past decade, stream crossing design at roadways has changed to address the deficiencies that the draft Assessment cites as having the potential impacts in the study area. The conclusions in the Assessment Report are therefore inaccurate and not based on the best available scientific and engineering information. (Doc. #4962, p. 8)
- **Modern design standards for road culverts will prevent the fish impacts that the Assessment erroneously predicts.** Road culverts are designed for two primary situations: 1) drainage without fish passage; and 2) drainage with fish passage requirements. Culvert design for fish passage has become progressively more sophisticated in the past decade, resulting in culverts that address fish passage, habitat continuity, and channel stability. The new design criteria for fish passage culverts typically produce a culvert with a much greater flow capacity, resulting in lower failure potential. The analysis of road and culvert failure in the Assessment does not address the distinction between the two culvert types, or describe

adequately the advances in design criteria for fish passage, and therefore overstates the potential for failure of project culverts on fish bearing streams. (Doc. #4962, p. 9)

- The BBWA Assessment contains an analysis of the negative impacts of roads and culverts that is inconsistent with current construction practices, as well as state and federal requirements. The authors appear to be unfamiliar with modern road building design and culvert placement requirements. Assumptions that culverts would block access to large portions of the existing natural habitat is unwarranted if modern road building techniques are adopted that meet current state and federal construction requirements. (Doc. #4962, p. 14)
- Approximately two-thirds of the impact assessment section of the BBWA Assessment focuses on the potential failure of tailings storage facilities (TSFs). The document estimates that the probability of occurrence of a tailing pond failure is extremely low. If the analysis of that probability excluded dams that do not conform to current mining practices and U.S. regulatory requirements, then the estimated probability of occurrence would be significantly lower. The analysis also assumes that no cleanup or remediation activities would be required upon the failure of a TSF, which is a highly unrealistic assumption. Most, if not all, of the TSF failure scenarios identified in the BBWA Assessment can be prevented through proper engineering design, and through the implementation of current Best Management Practices. (Doc. #4962, p. 14)
- Impacts are calculated in percentages, or at times fractions of percentages. This gives the reader two illusions: 1) that the impacts are real, and that 2) the impacts have been scientifically and defensibly calculated. Neither of these conditions is true. There is no project from which one could make valid impact assessment statements and no data has been collected from which one could actually calculate real or projected impacts. These flaws make all percentage-based analysis used throughout the document scientifically deficient. (Doc. #4962, p.15)
- The input assumptions used in the hydrological modeling are incorrect. For instance, an SCS-Type IA storm was used in developing one of the models used in the assessment. Based on known data for Alaska, a different SCS Type I distribution should have been used. Applying a different distribution would change the results of the analysis and reduce some of the greatly exaggerated results. (Doc. #4962, p.15)
- The pipeline failure rates used in the assessment are based on aggregated information from several countries spanning a wide range of construction techniques and pipe sizes. The estimate of expected pipe failure rate in the hypothetical mining scenario should be based on failure rates of pipelines of similar size and construction that would be used in the hypothetical mine and built and maintained to U.S. standards. The failure rate number on Table 4-14 of the BBWA Assessment that would be more applicable to USEPA's analysis is the average reported for U.S. oil pipeline operators, which is roughly 1/4 of the rate assumed in the assessment. (Doc. #4962, p.15)
- In the past decade, substantial changes in requirements for road culvert design have been adopted across the United States, including in Alaska, in response to studies that analyzed fish passage barriers and culvert failures. EPA's BBWA Assessment must assume that the current standards for culvert design and placement will be implemented. Failure rates for road culverts that do not meet current standards are not relevant, but that is precisely the data USEPA relied on in its report. To be scientifically valid, the assessment should be based on current road and culvert design and engineering standards. (Doc. #4962, p.16)
- Section 4.4.2.4, Box 4-7, page 4-52. It appears that a SCS-Type IA storm category was used

in developing the probable maximum flood (PMF). The SCS map and many other maps clearly show that only SCS Type I distribution should be used in Alaska. Applying different distribution will change results of the analysis, and reduce the impacts described in the analysis. (Doc. #4962, p. 19)

- Section 4.4.2.4, p. 4-59, Table 4-13. The sudden increase in the volume of deposition at RM 0.6 under the full failure scenario does not appear to be correct. The analysis in this section appears to be in error. (Doc. #4962, p. 20)
- Section 4.4.2.1. All of the listed causes of failure can be avoided through proper design of the project. Failures should not be assumed in the assessment. Rather, the assessment should assume that the mine design will appropriately address the potential for dam failure, which is consistent with current practices in the mining industry. (Doc. #4962, p. 20)
- Section 4.4, page 4-38, Box 4-3. The overall intent of this box is unclear. The text suggests that earthquakes may occur in the region and that activity may or may not be significant. The summary in Box 4-3 describes local faults (near Lake Clark and in the lliamna Lake region) and the known activity on those faults, indicating that activity on major faults has been minimal and that smaller faults in the area have "very limited capability to produce damaging earthquakes". However, the next paragraph discusses, in general terms, unpredictable "floating earthquakes" and stress induced earthquakes. The assessment fails to explain the significance of earthquake risks relative to mine operations. The information that is provided in the assessment is contradictory. (Doc. #4962, p. 21)
- Section 4.4.2.1, page 4-43. Box 4-5 (paragraph 3) states "Such displacement is not likely to occur in the Bristol Bay watershed because of the absence of large faults, but there is a potential for a small amount of ground spreading and cracking from larger earthquakes". This statement contradicts the final paragraph in Box 4-3, which emphasizes that there is a significant amount of uncertainty around predicting seismic activity in the Bristol Bay area. In addition, Box 4-3 notes that while there is no evidence of the Lake Clark Fault extending close to the hypothesized mine site, "mapping the extent of subsurface faults over long, remote distances is difficult and has a high level of uncertainty." The assessment fails to explain the significance of earthquake risks relative to mine operations, and the information that is provided is contradictory. (Doc. #4962, p. 21)
- Section 4.4.4, 2nd paragraph. In the past decade, substantial changes in requirements for culvert design have been adopted across the country in response to studies documenting passage barriers and culvert failures. The assessment must assume that the current standards for culvert design and placement will be implemented. Failure rates of culverts that do not meet current standards are not applicable in the assessment. This section should include a discussion of the current standards and the expected failure rate of culverts installed using current standards. (Doc. #4962, p.26)
- Section 4.4.2, page 4-40, paragraph 1, last sentence. The international examples of tailing dam failures do not appear to be relevant given the differences between US standards and standards in the cited countries. (Doc. #4962, p. 28)
- Section 4.4.2.2, page 4-44, both Paragraphs. The use of the tailing dam failure information worldwide from 1917 to 2000 is inappropriate. A large proportion of the failures were likely due to construction that did not incorporate modern standards used in the U.S. (Doc. #4962, p. 28)
- Section 4.4.3.1. The pipeline failure rates used in this section are based on aggregated

information from several countries spanning a wide range of construction techniques and pipe sizes. The estimate of expected pipe failure rate should be based on failure rates of pipelines of similar size and construction that would be used in the hypothetical mine and built and maintained to U.S. standards. The number on Table 4-14 that may be most applicable to the assessment is the average reported for U.S. oil pipeline operators, which is roughly 114 of the rate assumed in the document. The citation for URS (2000) is missing, thus the analysis and assumptions could not be evaluated. Still, if older pipelines built to an older standard are included in the average number, then the expected failure rate of a modern pipeline would be expected to be even lower than the average reported by URS. This section needs to be revised. Failure rates must be used that are, in fact, comparable. This section also needs to discuss the types of failures. What proportion are catastrophic failures and what portions are leaks? The type of failure affects the likely impacts of the failure. (Doc. #4962, p. 29)

- Section 4, page4-38 (PDF page 127). Citations are missing describing the source for the statements in this section, many of which are overly simplified. (Doc. #4962, p. 30)
- Section 4.4.2.1, page 4-43 (PDF page 132). Citations are missing describing references for the following statements: (a) "...because these deposits are typically in low gradient reaches they are less susceptible to liquefaction damage." (b) "Such displacement [along a fault]" (i.e., several meters) "is not likely to occur in the Bristol Bay watershed because of the absence of large faults, but there is a potential for a small amount of ground spreading and cracking from larger earthquakes". (Doc. #4962, p. 30)
- Section 4.4.4, 2nd paragraph. There are no citations or data presented to support this section. (Doc. #4962, p. 30)
- Section 4.4.2.4, page 4-55, third paragraph. The numbers in the text do not match the numbers on the tables. (Doc. #4962, p. 30)
- Section 4.4.2.2, page 4-48 (PDF page137). Citations are missing describing the source of information used to support the analysis described in this box. Without adequate supporting references and citations, the analysis is weak and unsupported. For example, reference is made to Alaska dam safety guidance, but no citation is provided. No other Alaska (state) or Federal regulations for design criteria are cited in this box. Citations are required where specific requirements or examples are cited (e.g., "For a Class II dam, the return period that must be considered for the OBE is 70 to 200 years-that is, the OBE represents the largest earthquake likely to occur in 70 to 200 years"). This statement requires documentation. (Doc. #4962, p. 31)
- Section 4.4.2.2, page 4-48 (PDF page137). The citation NDM 2006 is not listed in the references. (Doc. #4962, p. 31)
- Section 4.4.3.1, first 3 paragraphs. These paragraphs include many numbers with no units. Based on the text, we assume the unit is number of failures per km per year. Units need to be added to the text. (Doc. #4962, p. 31)
- Section 4.4.3.1, page 4-61 (PDF page150). Several documents are cited that are missing in the reference section. The information cited in the document could not be verified. For example: (a) OGP 2010 - Is the correct citation the document found at http://www.ogpageorg.uk/pubs/434-4.pdf ? (b) Caleyo 2007 - Is the correct citation the document found at http://iopscience.iopageorg/0957- 0233/18/7/001/ ? (c) URS 2000 -What is the correct citation for this document? (d) Alberta Metal - Is the correct citation the

document found at http://www.albertametal.ca/resources/alberta-metal-aicles/lS2-pipeline-failure-rate-is-improving.html? (Doc. #4962, p. 31)

- Section 4.4.3.1, page 4-61 (PDF page 150). OGP 2010: See comment above about lack of proper citation. It is assumed that the source being referenced is this: http://www.ogpageorg.uk/pubs/434-4.pdf. The data included in Table 4-14 generally matches the information provided in the article assumed to be the source, except: -Failure rates for various wall thickness values (e.g., <5 mm) presented in Table 4-14 are listed under the oil pipeline category, while the source document only presents failure rates for gas pipeline wall thickness values. -The wall thickness presented does not match what is in the source document: "Wall thickness 5-10mm" should be Wall thickness S< - 10mm. (Doc. #4962, p. 31)
- **Tailings Dam Failure** The Assessment Report has misrepresented the likelihood of tailings dam failure for any proposed mining development in Alaska. The International Commission on Large Dams (ICOLD) tailings dam failure statistics are extensively referenced in the Assessment Report, either directly or indirectly through selectively citing other technical articles. However, these ICOLD statistics do not support the premise that tailings dam failure is a reasonable hypothesis for a modern mine operation in the Bristol Bay watershed. Examination of the ICOLD statistics on tailings dam failures shows that the vast majority of historical tailings dam failures resulted from tailings impoundments constructed using the upstream method (Figures 1 and 2), which would not be permitted in Alaska. (Doc. #4962, p. 41)
- The Assessment Report also provides numerous references from various technical publications to reinforce their flawed 'tailings dam failure premise'. Most of the publications include confirmation that tailings dams can be constructed and operated in a stable and responsible manner. The COLD document provides some summary statistics on the frequency of tailings dam failures and states the following; "In highlighting accidents, the aim is to learn from them, not to condemn". Similarly, other authors have studied and expanded the database of tailings dam failures in an effort to prevent future incidents. These authors generally do not suggest that these statistics represent a probability of failure for any specific tailings dam, but rather they indicate that the objective is to essentially eliminate such events with an industry-wide commitment to correct design and stewardship practices. Conversely, the Assessment Report incorrectly implies that generalized statistics for worldwide tailings dam failures can be applied to individual tailings dams to suggest a high potential for failure over an extended period of time. This premise is erroneous and misleading, as it is incorrect to imply that any particular proposed or actual dam structure is more or less likely to fail based solely on extrapolation of general dam failure statistics. The integrity and stability of any dam structure should rather be ascertained by suitably qualified and competent professionals, whose assessment must take into consideration all relevant aspects of the specific site conditions; the details of the design; as well as the construction, operating and closure parameters that are relevant to the evaluation. The Assessment Report fails to take into account these critical analyses and cannot be used to reasonably predict how an actual mine would perform in the Bristol Bay region. (Doc. #4962, p. 43)
- **Hydrology and Dam Breach Model** The Assessment Report includes a questionable dam breach assessment where the high uncertainty associated with the peak flow estimate and modeling predictions is not presented, and where the relative magnitude of the dam breach flood is speciously presented.

Dam breach modeling involves a number of assumptions and approximations, and the results are highly dependent on the selected input parameters, such as the total volume of material released, the size of the dam breach, the rate of breach development, and the magnitude of the breach triggering flood. Only the triggering flood was discussed in the Assessment Report, and it was referred to as "a reasonable runoff hydrograph," which implies normalcy. In fact, the flood was due to the probable maximum precipitation (PMP) event, which is so extreme and unlikely that no probability can be assigned to it.

In an effort to illustrate the extreme magnitude of the dam breach flood, it was compared to a natural flood in the region, but errors were made in the calculations and the comparison was done in a spurious manner that exaggerates the result. The errors were in the drainage areas stated for both the dam breach flood and the regional flood, and we suspect that they stem from an inability to simply convert from imperial units to metric units (sq. miles to equivalent sq. kilometers). The speciousness of the assessment stems from the inappropriateness of the flood chosen for comparison with the dam breach flood. Firstly, it is not valid to compare an extreme theoretical flood with a common historical flood. The dam breach flood results from an event so extreme that it reasonably can never be expected to occur, while the selected historical flood is only the largest event in a 16 year flood record, and has a return period of between 20 and 25 years, which corresponds to a probability of occurrence in any year of approximately 4% to 5%. Secondly, it is not clear why this particular regional flood was selected, since far more extreme floods are available in the relatively short-term historical flood record for the region. The 2004 flood on the lliamna River, for instance, is 35 times greater on a unit area than the selected flood. And thirdly, it is well known that peak flows typically have a non-linear scaling relationship, with small basins in a region having higher unit flows than large basins, so it is not valid to directly compare unit peak flows from the TSF with those from a basin that is 1821 times greater in area. All of these factors result in an exaggeration of the relative magnitude of the dam breach flood.

The lack of rigor used in these analyses results in misleading statements concerning the potential impacts of mining development in Bristol Bay. (Doc. #4962, p. 44)

- **Earthquake and Seismic Activity** The potential for accidents and failures resulting from earthquakes is represented as a particular concern for the hypothetical mine scenario presented in the Assessment Report, which also implies that the seismic activity of the region means that dam failures are 'likely to occur'. This is incorrect, as the mine development would not be permitted or allowed to proceed if this were true. The assessment of earthquake probabilities and the development of appropriate site specific seismic parameters for the design of the various project components is a normal part of the design, review and permitting processes. It is improper and incorrect to imply that 'failures are likely to occur' simply because earthquake probabilities must be taken into account. Tailings and water dams have been, and continue to be, successfully designed, constructed and operated in seismically active regions in Alaska and elsewhere in the world. (Doc. #4962, p. 45)
- **Box 4-8. Modeling Hydrologic Characteristics of Tailings Dam Failures: 4-53** If sufficient freeboard is maintained, it would be possible to capture and retain the expected volume of the PMF in the TSF. However, to examine potential downstream effects in the event of a tailings dam failure, we assume that sufficient freeboard would not exist and overtopping would occur. This may be less likely when the TSF would be actively monitored and maintained, but may be more representative of post-closure conditions.

AT POST-CLOSURE THE FACILITY WOULD HAVE A SPILLWAY THAT WOULD SAFELY CONVEY THE PEAK FLOW OF THE PMF, SO IT IS NOT POSSIBLE THAT THIS EVENT WOULD OCCUR AS ASSUMED.

ON-GOING MONITORING AND MAINTENANCE IS INEVITABLE AND THE ASSESSMENT REPORT ASSUMPTION OF SITE ABANDONMENT IS NOT REALISTIC BECAUSE IT IS ILLEGAL (AND/OR NON-PERMITABLE).

THE FAILURE MECHANISM IS CLEARLY STATED AS AVOIDABLE, BUT IN A SUBTEXT BOX AND ONLY ONCE. IT ALSO STATES THAT OVERTOPPING IS "MORE REPRESENTATIVE OF POST-CLOSURE CONDITIONS"; HOWEVER IN A DISCUSSION ABOUT CLOSURE IT STATES THAT POST-CLOSURE THE LIKELIHOOD OF FAILURE FROM OVERTOPPING IS REDUCED. THE STATEMENTS ARE INCONSISTENT AND CONTRADICTORY. (Doc. #4962, p. 47)

- **4.4 Mine Scenario: Failure: 4-37** Our mine scenario assumes that engineering controls would be designed to capture and treat all surface and groundwater runoff from the site, and that no discharges would exceed existing water quality standards. However, human-engineered systems are imperfect: based on the experience of most large engineering projects, accidents and failures are likely to occur over the decades that a mine is in operation, and over the centuries that a TSF remains in the post-closure period and requires maintenance and monitoring. The potential for accidents and failures resulting from earthquakes may be of particular concern in our mine scenario, given that southwestern Alaska is a seismically active region.
  THIS IMPLIES THAT FAILURES ARE "LIKELY TO OCCUR" WHICH IS NOT CORRECT. THE MINE DEVELOPMENT WOULD NOT BE PERMITTED IF THIS WERE TRUE. THIS SEISMIC ACTIVITY ASSESSMENT IS PART OF A "NORMAL" REVIEW AND PERMITTING PROCESS AND CANNOT BE ASSUMED ARBITRARILY IN ADVANCE OF ANY PARTICULAR AND SITE-SPECIFIC MINE DESIGN. EARTHQUAKES MUST BE CONSIDERED IN THE DESIGN PHASE OF MINING PROJECTS, BUT IT IS ENTIRELY IMPROPER TO IMPLY THAT "FAILURES ARE LIKELY TO OCCUR" SIMPLY BECAUSE EARTHQUAKE PROBABILITIES MUST BE TAKEN INTO ACCOUNT. (Doc. #4962, p. 49-50)
- **Box 4-3 Seismic Environment: 4-38** USGS has concluded that there is no evidence for fault activity or seismic hazard associated with the Lake Clark Fault in the past 1.8 million years, and no evidence of movement along the fault northeast of the Pebble deposit since the last glaciations 11,000 to 12,000 years ago (Haeussler and Waythomas 2011). Recently, the Alaska Division of Geological and Geophysical Surveys and USGS investigated reports of a surface geological feature (the Braid Scarp) near the Pebble deposit that was reported to be a fault scarp, indicating recent movement of a fault (Koehler and Reger 2011, Haeussler and Waythomas 2011). Both agencies independently determined that the feature was a relic of glacial activity and did not represent evidence of recent faulting. Geologic mapping conducted by consulting firms for the Pebble Limited Partnership (PLP) identified numerous faults in the area of the Pebble deposit. The mapped faults shown in both these sources are all considerably shorter than the Lake Clark Fault, and therefore by themselves have a very limited capability to produce damaging earthquakes.
  THIS IS AN EXAMPLE FROM THE ASSESSMENT REPORT INDICATING THAT SEVERAL INDEPENDENT INVESTIGATIONS HAVE CONCLUDED THAT RISK OF SEISMIC ACTIVITY IS LESS SIGNIFICANT THAN IMPLIED ELSEWHERE IN THE ASSESSMENT REPORT. (Doc. #4962, p. 50)
- **Box 4-3 Seismic Environment: 4-38** Interpreting the seismicity in the Bristol Bay area is difficult because of the remoteness of the area for study, lack of historical records on seismicity, and complex bedrock geology that is overlain by multiple episodes of glacial

activity. Thus, there is a high degree of uncertainty in determining the location and extent of faults, their capability to produce earthquakes, whether these or other geologic features have been the source of past earthquakes, and whether they have a realistic potential for producing future earthquakes.
THIS SUMMARY DISCOUNTS THE PREVIOUSLY STATED STUDIES, AND ILLUSTRATES A DEMONSTRATED TENDENCY TO DISCOUNT THE EVIDENCE CONTRARY TO EPA'S OVERALL PERSPECTIVE PROMOTED IN MANY SECTIONS OF THE ASSESSMENT REPORT. (Doc. #4962, p. 50)

- **Box 4-6: 4-48.** The Northern Dynasty Minerals Preliminary Assessment (NDM 2006) identified the following design criteria for the tailings storage facility. OBE return period of 200 years, magnitude 7.5. MDE return period of 2,500 years, magnitude 7.8, with maximum ground acceleration of 0.3g, based on Castle Mountain Fault data.
  THESE APPEAR TO BE MINIMUM CRITERIA BASED ON REQUIREMENTS STIPULATED IN ALASKA DAM SAFETY REGULATIONS. THESE CRITERIA SHOULD BE RECOGNIZED AS A MINIMUM REQUIREMENT, AND IT IS ACTUALLY MUCH MORE LIKELY THAT MORE STRINGENT CRITERIA WOULD BE REQUIRED AND IMPLEMENTED FOR THE DETAILED DESIGN OF THE TAILINGS STORAGE FACILITY. (Doc. #4962, p. 50-51)
- **Case Histories Box 4-4 Examples of Historical Tailings Dam Failures: 4-41** Aznalcollar Tailings Dam, Los Frailes Mine, Seville, Spain, 1998. A foundation failure resulted in a 45-mlong breach in the 27-m-high, 600-m-long tailings dam, releasing up to 6.8 million m3 of acidic tailings that traveled 40 km and covered 2.6 million ha of farmland (ICOLD 2001).
  THIS EXAMPLE OF FOUNDATION FAILURE RESULTED DUE TO THE PRESENCE OF A WEAK UNDERLYING MARL (MUDSTONE). SITE INVESTIGATIONS FOR THIS EXAMPLE WERE INADEQUATE; THIS IS NOT RELEVANT FOR THE PEBBLE DEPOSIT AS THESE GEOLOGICAL MATERIALS ARE NOT PRESENT IN THE REGION AND BECAUSE EXTENSIVE GEOTECHNICAL INVESTIGATIONS HAVE AND WILL BE CONDUCTED TO PROVE THE SUITABILITY OF THE FOUNDATIONS.

Stava, Italy, 1985. Two tailings impoundments were built, one upslope from the other, in the mountains of northern Italy. The upslope dam had a height of 29 m; the downslope dam had a height of 26 m. A stability failure of the upper dam released tailings, which then caused the lower dam to fail. The 190,000 m3 of tailings, traveling at up to 60 kmlhour, reached the village of Tesero 4 km downslope from the point of release, in 5 or 6 minutes. The failure killed 269 people (ICOLD 2001).
THIS EXAMPLE IS OF DECANT FAILURE CAUSING A RISE IN THE PHREATIC SURFACE RESULTING IN ROTATIONAL SLIPS ON THE DOWNSTREAM SLOPE. THE DAMS WERE DEVELOPED USING UPSTREAM AND CENTERLINE CONSTRUCTION BY UNCOMPACTED, HYDRAULICALLY PLACED CYCLONE SAND MATERIAL. THIS IS OLD AND POOR TECHNOLOGY THAT IS NOT RELEVANT TO THE TAILINGS DAM CONCEPT PRESENTED IN THE ASSESSMENT REPORT.
Aurul S.A. Mine, Baia Mare, Romania, 2000. A 5-km-long, 7-m-high embankment on flat land enclosed a tailings impoundment containing a slurry with high concentrations of cyanide and heavy metals. Heavy rains and a sudden thaw caused overtopping of the embankment, cut a 20- to 25-m breach, and released 100,000 m3 of contaminated water into the Somes and Tisza Rivers. Flow continued into the Danube River and eventually reached the Black Sea. The contamination caused an extensive fishkill and the destruction of aquatic species over 1,900 km of the river system (ICOLD 2001).
THIS IS AN EXAMPLE OF POOR OPERATION AND INADEQUATE REGULATIONS AT A GOLD MINE

OPERATION IN ROMANIA. THE FAILURE RESULTED FROM OVERTOPPING WHICH CAUSED RAPID EROSION AND FAILURE OF AN ERODIBLE CYCLONE SAND TAILINGS DAM. THIS EXAMPLE IS NOT RELEVANT TO A MAJOR MINE DEVELOPMENT IN ALASKA AS REGULATIONS AND ONGOING DESIGN/OPERATIONS REVIEW PROCESSES ARE MORE SOPHISTICATED THAN THOSE IMPLEMENTED AT THE AURUL MINE IN ROMANIA. THIS FAILURE EXAMPLE IS NOT RELEVANT FOR THE ROCKFILL DAM CONCEPT PRESENTED IN THE ASSESSMENT REPORT.

Tennessee Valley Authority Kingston Fossil Plant, Roane County, Tennessee, 2008. After receiving nearly 20 cm of rain in less than 4 weeks, an engineered 18-m-high earthen embankment of a 34-ha storage impoundment failed, producing a 14-m-high surge wave and releasing 4.1 million m3 of coal fly ash slurry. The release covered over 121 ha with slurry containing arsenic, cobalt, iron, and thallium. Over 2.7 million m3 of coal ash and sediment were dredged from the Emory River to prevent further downstream contamination (AECOM 2009).

THE FAILURE OF THIS EARTHEN (FLY ASH) UPSTREAM CONSTRUCTION DAM THAT WAS FOUNDED ON SILT AND CLAY IS NOT COMPARABLE TO A MAJOR MINE DEVELOPMENT IN ALASKA. THE FAILURE WAS ATTRIBUTED TO THE FOUNDATION, CONSTRUCTION RATE, CONSTRUCTION MATERIAL, AND PLACEMENT METHOD (LACK OF COMPACTION). NONE OF THESE FACTORS ARE RELEVANT FOR THE TAILINGS DAM CONCEPT PRESENTED IN THE ASSESSMENT REPORT (Doc. #4962, p. 51 to 52)

- **References to dam failures**
  THERE ARE 186 REFERENCES TO DAM FAILURE IN THE ASSESSMENT REPORT (INCLUDING HEADINGS, FIGURES, AND APPENDICES). THIS ILLUSTRATES A BIASED PERSPECTIVE. THE ASSESSMENT REPORT RELIES HEAVILY ON THE PREMISE THAT "IT IS NOT A MATTER OF IF BUT WHEN A TAILINGS DAM FAILURE WILL OCCUR". MULTIPLE ATTEMPTS TO JUSTIFY THIS FALSE PREMISE ARE PRESENTED BY REPEATED ASSERTIONS THAT FAILURE “COULD” OCCUR AND BY QUOTING SEVERAL TECHNICAL PAPERS OUT OF CONTEXT. EPA'S ASSERTIONS LACK SCIENTIFIC FOUNDATION AND DO NOT REFLECT REALITY. AS SUCH, THE CONCLUSIONS CONTAINED IN THE ASSESSMENT REPORT REGARDING DAM FAILURES ARE INVALID. (Doc. #4962, p. 52)
- **Executive Summary: ES-22** Multiple, simultaneous failures could occur as a result of a common event, such as the occurrence of a severe storm with heavy precipitation (particularly one that fell on spring snow cover) or a major earthquake. Such an event could cause one to three tailings dam failures that would spill tailings slurry into streams and rivers, road culvert washouts that would send sediments downstream and potentially block fish passage, and pipeline failures that would release product slurry, return water, or diesel fuel.

THE PREMISE THAT FAILURES "COULD OCCUR" OR "HAVE THE POTENTIAL TO OCCUR" IS BASED ON THE FACT THAT ISOLATED TAILINGS DAM FAILURES HAVE OCCURRED IN THE PAST AND IMPLIES THAT ALL TAILINGS DAM HAVE AND WILL BE CONSTRUCTED AND OPERATED USING SIMILAR STANDARDS AND METHODS. IT IS ALSO IMPLIED THAT THE LESS CONSERVATIVE TAILINGS MANAGEMENT PRACTICES THAT LED TO DAM FAILURE IN THE PAST WOULD BE APPLIED FOR FUTURE PROJECTS IN ALASKA. THIS PREMISE IS WRONG. SUITABLY QUALIFIED AND COMPETENT PROFESSIONALS WOULD NOT DESIGN FOR FAILURE NOR WOULD IT BE ALLOWED BY A DILIGENT REGULATORY PROCESS. THE EXAMPLES OF TAILINGS DAM FAILURES IN THE ASSESSMENT REPORT ARE NOT APPLICABLE AS THEY WERE DUE TO DESIGN FEATURES THAT WOULD NOT BE APPLIED IN A CURRENT MINE DESIGN. IT IS ALSO USEFUL TO NOTE THAT SOME SECTIONS OF THE ASSESSMENT REPORT DEPICT A MORE BALANCED PERSPECTIVE. IN PARTICULAR, IT IS USEFUL TO REVIEWAPPENDIX1 FOR A BETTER TECHNICAL

PERSPECTIVE THAN IS PRESENTED ELSEWHERE IN THE ASSESSMENT REPORT. (Doc. #4962, p. 53)

- **4.4.2.1 Causes of Tailings Dam Failures: 4-44** Perhaps most noteworthy is the relatively high number of accidents or failures for active tailings dams relative to inactive tailings dams, primarily resulting from slope instability failure (Table 4-8). This suggests that the stability of tailings dams and impoundments may increase with time, as dewatering and consolidation of the tailings occurs and with the cessation of the application of additional loads (however, see Section 4.3.8.2).

THESE TWO STATEMENTS FROM THE ASSESSMENT REPORT ARE CONTRADICTORY. IF THE STABILITY OF TAILINGS DAMS AND IMPOUNDMENTS INCREASES OVER TIME (AS EVIDENCED BY THE LOW NUMBER OF FAILURES AT INACTIVE DAMS), THEN THE ASSUMPTION THAT THE PROBABILITY OF FAILURE INCREASES OVER TIME IS INCONSISTENT, AND INCORRECT (Doc. #4962, p. 53 to54)

- **Table ES-1 Summary of Probability and Consequences of Potential Failures: ES-16**

Failure Type: Tailings dam

Probability: 10^4 to 10^6 per dam-year = recurrence frequency of 10,000 to 1 million years Consequences: More than 30 km of salmonid stream would be destroyed and more streams and rivers would have greatly degraded habitat for decades.

THIS STATEMENT SUGGESTS THAT IT IS REASONABLE AND APPROPRIATE TO ASSIGN A 'RECURRENCE FREQUENCY' FOR TAILINGS DAM FAILURE. THIS IS INCORRECT AND MISLEADING. IT COULD ALSO BE NOTED THAT EVEN IF THIS HYPOTHESIS WERE CORRECT, IT IS SOMEWHAT RIDICULOUS AS EXTRAPOLATION OF SUCH A FAILURE EVENT TO A PERIOD OF TIME 10,000 TO 1 MILLION YEARS IN THE FUTURE IS POINTLESS. FOR COMPARISON PURPOSES, LOOKING BACK ABOUT 10,000 YEARS WOULD SHOW THAT THE ENTIRE BRISTOL BAY AREA WAS COVERED BY MASSIVE GLACIERS AND THEREFORE DEVOID OF ANY SALMONID STREAMS. (Doc. #4962, p. 54)

- **Executive Summary: ES-18** The range of estimated probabilities of dam failure is wide, reflecting the great uncertainty concerning such failures. The most straightforward method of estimating the annual probability of failure of a tailings dam is to use the historical failure rate of similar dams. Three reviews of tailings dam failures produced an average rate of approximately 1 failure per 2,000 dam years, or 5 x lo4 failures per dam year. The argument against this approach is that it does not fully reflect current engineering practice. Some studies suggest that improved design, construction, and monitoring practices can reduce the failure rate by an order of magnitude or more, resulting in an estimated failure probability within our assumed range. The State of Alaska's guidelines suggest that an applicant follow accepted industry design practices such as those provided by the U.S. Army Corps of Engineers (USACE), Federal Energy Regulatory Commission (FERC), and other agencies. Both USACE and FERC require a minimum factor of safety of 1.5 against slope instability, for the loading condition corresponding to steady seepage from the maximum storage facility. An assessment of the correlation of dam failure probabilities with safety factors against slope instability suggests an annual probability of failure of 1 in 1,000,000 for Category I Facilities (those designed, built, and operated with state-of-the-practice engineering) and 1 in 10,000 for Category II Facilities (those designed, built, and operated using standard engineering practice). This spans the failure frequency used in our failure assessment. The advantage of this approach is that it addresses current regulatory guidelines and engineering practices.

THE STATISTICS FOR TAILINGS DAM FAILURE PROBABILITY IN THE ASSESSMENT REPORT ARE FLAWED, THUS THEY MUST BE IGNORED. EVEN IF IT WERE ACCEPTED THAT THIS APPROACH IS REASONABLE, THEN A LOGICAL CONCLUSION WOULD BE TO ASSIGN THE 1 IN A MILLION PROBABILITY (I.E. THE LOWEST PROBABILITY THAT SILVA ET AL. (2008) COULD ASCRIBE I.E. NEGLIGIBLE RISK). (Doc. #4962, p. 54 to 55)

- **Executive Summary Tailings Dam Failure: ES-15 to ES-18** The range of estimated probabilities of dam failure is wide, reflecting the great uncertainty concerning such failures. The most straightforward method of estimating the annual probability of failure of a tailings dam is to use the historical failure rate of similar dams. Three reviews of tailings dam failures produced an average rate of approximately 1 failure per 2,000 dam years, or 5 x lo4 failures per dam year. The argument against this approach is that it does not fully reflect current engineering practice. Some studies suggest that improved design, construction, and monitoring practices can reduce the failure rate by an order of magnitude or more, resulting in an estimated failure probability within our assumed range.

THE AUTHOR CLEARLY STATES A REVIEW OF "SIMILAR DAMS': HOWEVER SIMILAR IN THIS SENSE REFERS TO "ALL TAILINGS DAMS" AND INCLUDES TAILINGS DAMS CONSTRUCTED BY THE UPSTREAM CONSTRUCTION METHOD. THIS IS INCORRECT AND MISLEADING. FAILURE PROBABILITY IN THE ASSESSMENT REPORT HAS BEEN EXTRAPOLATED FROM A DATA SET THAT IS NOT RELEVANT TO A REALISTIC PROPOSAL FOR DEVELOPMENT OF A TAILINGS DAM IN ALASKA. (Doc. #4962, p. 55)

- **Executive Summary Tailings Dam Failure: ES-15 to ES-18** An assessment of the correlation of dam failure probabilities with safety factors against slope instability suggests an annual probability of failure of 1 in 1,000,000 for Category I Facilities (those designed, built, and operated with state-of-the-practice engineering) and 1 in 10,000 for Category II Facilities (those designed, built, and operated using standard engineering practice). This spans the failure frequency used in our failure assessment. The advantage of this approach is that it addresses current regulatory guidelines and engineering practices. The disadvantage is that we do not know whether standard practice or state-of-the practice dams will perform as expected, particularly given the large size of potential dams. In addition, slope instability is only one type of failure; other failure modes, such as overtopping during a flood, would increase overall failure rates.

THIS EXCERPT FROM THE EXECUTIVE SUMMARY IS BASED ON A FLAWED INTERPRETATION OF THE SILVA ET AL. (2008) PAPER. THIS PAPER BY SILVA, LAMBE, AND MARR PRESENTS A METHODOLOGY TO ALLOW GEOTECHNICAL ENGINEERS TO EVALUATE "TOLERABLE RISK". THEY PROVIDE A SPECIFIC EXAMPLE FOR A TAILINGS DAM WHERE "CORPORATE MANAGEMENT WANTED TO INCREASE THE LEVEL OF SAFETY OF THE FLUID RETENTION SYSTEM TO REDUCE THE RISK OF RELEASE ... THAT COULD CONTAMINATE THE PRISTINE RIVER DOWNSTREAM OF THE MINE SURFACE FACILITIES." THEY DESCRIBE THIS METHOD AS A TOOL TO JUSTIFY INCREASINGLY CONSERVATIVE AND MORE COSTLY DESIGN SOLUTIONS TO REDUCE THE RISK TO AN APPROPRIATE LEVEL. DIRECT EXTENSION OF THE CONCEPTS IN THE SILVA PAPER WOULD LEAD TO THE CONCLUSION THAT TAILINGS DAMS IN THE BRISTOL BAY WATERSHED WOULD BE DESIGNED AND CONSTRUCTED TO HAVE AN EXTREMELY LOW RISK OF FAILURE. IF THE CONSEQUENCES OF FAILURE ARE HIGH THEN THE DESIGNS CAN BE ADJUSTED TO ENSURE THAT THE LIKELIHOOD OF FAILURE IS VERY LOW. SILVA ET AL. (2008) DO NOT IMPLY THAT THIS TOOL CAN BE USED TO ASSIGN A PROBABILITY OF FAILURE TO A HYPOTHETICAL STRUCTURE THAT HAS NOT YET BEEN DESIGNED. (Doc. #4962, p. 55 to 56)

- **4.4.2.2 Probability of Tailings Dam Failures: 4-46** Silva et al. (2008) reported on over 75 earth dams, tailings dams, natural and cut slopes, and some earth retaining structures to illustrate the relationship between the annual probability of slope failure in earth structures and factors of safety. They grouped projects into four categories based on the level of engineering applied to the design, site investigation, materials testing, analysis, construction control, operation, and monitoring of each project.
    - Category I: Facilities designed, built, and operated with state-of-the-practice engineering. Generally these facilities are constructed to higher standards because they have high failure consequences.
    - Category II: Facilities designed, built, and operated using standard engineering practice. Many ordinary facilities fall into this category.

The tailings dams in our mine scenario would be classified as either Category I or Category II, both of which require a detailed computer stability analysis with verification by other methods, and may require more sophisticated finite element analyses in special circumstances.

Both USACE and FERC require a minimum factor of safety of 1.5 for the loading condition corresponding to steady seepage with the maximum storage pool (FERC 1991, USACE 2003).

Combining the required factor of safety with the correlations between slope failure probability and factor of safety (Figure 4-12) derived from Silva et al. (2008) yields an expected annual probability of slope failure between 0.000001 and 0.0001. This translates to one tailings dam failure every 10,000 to 1 million mine years. The upper bound of this range is lower than the historic average of 0.00050 (1 failure every 2,000 mine years) for tailings dams, in part because slope failure is only one of several possible failure mechanisms, but also suggesting that past tailings dams may have been designed for lower safety factors or designed, constructed, operated, or monitored to lower engineering standards. Because 90% of tailings dam failures have occurred in active dams (Table 4-8), the probability of a tailings dam failure after TSF closure would be expected to be lower than the historical average for all tailings dams. However, Morgenstern (2011), in reviewing data from Davies and Martin (2009), did not observe a substantial downward trend in failure rates over time.

THE ASSESSMENT REPORT SEEMS TO BASE COMMENTS ON A HYPOTHETICAL DAM THAT HAS BEEN DESIGNED TO PROBABLY FAIL. THEY ERRONEOUSLY ASSUME THAT THIS FLAWED DAM DESIGN CONCEPT COULD BE PERMITTED AND ALLOWED TO PROCEED INTO CONSTRUCTION AND OPERATION. THEY THEN SUGGEST THAT THIS WOULD RELATE TO "ANT" DAM IN THE BRISTOL BAY WATERSHED. IT WOULD HAVE BEEN MORE REALISTIC TO ASSUME THAT ANY TAILINGS DAM CONSTRUCTED IN THE BRISTOL BAY WATERSHED WOULD NEED TO BE CONSISTENT WITH SILVA'S CATEGORY 1 DAMS. THE ANNUAL FAILURE PROBABILITY OF A DAM STRUCTURE DESIGNED TO ACHIEVE A FACTOR OF SAFETY OF 1.5 (WHICH IS THE MINIMUM) IS 1 IN A MILLION, I.E. THIS IS IMPLIED TO BE NEGLIGIBLE BY SILVA ET AL. (2008). IT WOULD ALSO BE MORE REASONABLE TO ASSUME THAT ANY TAILINGS DAMS CONSTRUCTED WITHIN THE BRISTOL BAY WATERSHED WOULD BE EXPECTED TO BE DESIGNED TO ACHIEVE AN EVEN HIGHER FACTOR OF SAFETY AND THUS WOULD ACHIEVE AN EVEN LOWER PROBABILITY OF FAILURE. THE ASSESSMENT REPORT IS THEREFORE INCORRECT. (Doc. #4962, p. 56 to 57)

- **4.4.2.2 Probability of Tailings Dam Failures: 4-45** An estimated 0.00050 failures per dam year, based on 88 failures from 1960 to 2010 (Chambers and Higman 2011). This translates to 1 tailings dam failure every 2,000 mine years.

THE AUTHORS INCORRECTLY IMPLY THAT GENERALIZED STATISTICS FOR WORLDWIDE TAILINGS DAM FAILURES CAN BE APPLIED TO INDIVIDUAL TAILINGS DAMS TO SUGGEST A HIGH POTENTIAL FOR FAILURE OVER AN EXTENDED PERIOD OF TIME. CHAMBERS AND HIGMAN (2011) INDICATE BY MEANS OF FLAWED LOGIC THAT "THE FAILURE RATE OF TAILINGS DAMS HAS REMAINED AT ROUGHLY ONE FAILURE EVERY 8 MONTHS .... OVER A 10,000 YEAR LIFESPAN THIS IMPLIES A SIGNIFICANT AND DISPROPORTIONATE CHANCE OF FAILURE FOR A TAILINGS DAM" (P. 4). THIS PREMISE IS ERRONEOUS AND MISLEADING, AS IT IS INCORRECT TO IMPLY THAT ANY PARTICULAR PROPOSED OR ACTUAL DAM STRUCTURE IS MORE OR LESS LIKELY TO FAIL BASED SOLELY ON EXTRAPOLATION OF GENERAL DAM FAILURE STATISTICS. THE INTEGRITY AND STABILITY OF ANY DAM STRUCTURE SHOULD RATHER BE ASCERTAINED BY SUITABLY QUALIFIED AND COMPETENT PROFESSIONALS, WHOSE ASSESSMENT MUST TAKE INTO CONSIDERATION ALL RELEVANT ASPECTS OF THE SPECIFIC SITE CONDITIONS; THE DETAILS OF THE DESIGN; AS WELL AS THE CONSTRUCTION, OPERATING AND CLOSURE PARAMETERS THAT ARE RELEVANT TO THE EVALUATION. (Doc. #4962, p. 57)

- **4.4.2.2 Probability of Tailings Dam Failures: 4-45** An estimated 0.00049 failures per dam year, based on 3,500 appreciable tailings dams that experienced an average 1.7 failures per year from 1987 to 2007 (Peck 2007). This translates to 1 tailings dam failure every 2,041 mine years.

PECK (2007) CITES NO REFERENCE FOR HIS FIGURE OF 1.7 FAILURES PER YEAR BUT IT IS ASSUMED TO BE SOURCED FROM INFORMATION PRESENTED IN ICOLD BULLETIN 121 AND POSSIBLY OTHER SOURCES AS WELL. THE ASSESSMENT REPORT ALSO APPEARS TO BE DRAWING REFERENCE TO DAVIES WITH THE STATED TOTAL OF 3,500 TAILINGS DAMS WORLDWIDE WHICH IS BASED ON A CONSERVATIVE ESTIMATE. THUS, THIS REFERENCE IS USED OUT OF CONTEXT. LRRESPECT1VE OF THE INCORRECT REPRESENTATION OF THE SOURCE MATERIAL THE DAM FAILURE DATA SET NEEDS TO BE FILTERED FOR CONSTRUCTION METHOD AND MATERIAL BEFORE MAKING ANY COMPARISONS TO THE HYPOTHETICAL DAM (CENTERLINE CONSTRUCTED ROCKFILL EMBANKMENT) THAT IS PRESENTED IN THE ASSESSMENT REPORT. CLOSE EXAMINATION OF THE ICOLD INFORMATION INDICATES THAT NONE OF THE HISTORICAL TAILINGS DAM FAILURES CAN BE DIRECTLY COMPARED TO THE DAM CONCEPT PRESENTED IN THE ASSESSMENT REPORT. THUS, PROPER APPLICATION OF DAM FAILURE STATISTICS INDICATES THAT DAM FAILURE IS NOT ONLY IMPROBABLE BUT IMPOSSIBLE FOR THE EXAMPLE USED IN THE ASSESSMENT REPORT. (Doc. #4962, p. 57 to58)

- **4.4.2.2 Probability of Tailings Dam Failures: 4-45** An estimated 0.00057 to 0.0014 failures per dam year, based on a database including many unpublished failures that showed 2 to 5 major tailings dam failures annually from 1970 to 2001 (Davies 2002, Davies et al. 2000). This translates to 1 tailings dam failure every 1,754 to 714 mine years.

DAVIES ET AL. (2000) PRESENTS SUMMARY STATISTICS OF "MAJOR" TAILINGS DAM INCIDENTS AND SUGGESTS THAT, BASED ON A TENUOUS EXTRAPOLATION TO A WORLDWIDE INVENTORY OF3500 TAILINGS DAMS, THAT "2 TO 5 FAILURES PER YEAR EQUATES TO AN ANNUAL PROBABILITY OF BETWEEN 1 IN 700 TO 1 IN 1750" (P. 4). IT IS IMPORTANT TO NOTE THAT3500 WORLDWIDE TAILINGS DAMS IS LIKELY AN UNDERESTIMATE, AS THERE ARE 1448 TAILINGS DAMS IN THE USA ALONE. DAVIES ET AL. (2000) ALSO DO NOT SUGGEST THAT THESE STATISTICS REPRESENT A PROBABILITY OF FAILURE FOR ANY SPECIFIC TAILINGS DAM, BUT RATHER INDICATE THAT "THERE IS THE POTENTIAL TO ESSENTIALLY ELIMINATE SUCH EVENTS WITH AN INDUSTRY-WIDE COMMITMENT TO CORRECT DESIGN AND STEWARDSHIP PRACTICES" (P. 11). (Doc. #4962, p. 58)

- **Box 4-7. Modeling the Probable Maximum Flood Hydrograph at TSF1 4-52** We used the U.S. Army Corps of Engineers (USACE) Hydrologic Engineering Center's Hydrologic Modeling System (HEC-HMS) to generate a reasonable runoff hydrograph based on a 24-hour probable maximum precipitation (PMP) event of 356 mm (14 inches) (Miller 1963).

THE USE OF THE PHRASE "A REASONABLE RUNOFF HYDROGRAPH" IMPLIES NORMALCY. THE FLOOD RESULTING FROM A PMP IS ANYTHING BUT "NORMAL". IT IS SO EXTREME AND UNLIKELY THAT NO PROBABILITY CAN BE ASSIGNED TO IT. (Doc. #4962, p. 60)

- **Box 4-8. Modeling Hydrologic Characteristics of Tailings Dam Failures 4-53** Under both partial and full TSF volume conditions, results were modeled for 30 km (18.6 miles) downstream-from the face of the hypothetical dam to the confluence of the North Fork Koktuli and South Fork Koktuli Rivers (Figure 4-14)-because extension of the simulation beyond this point would have introduced significant error and uncertainty associated with the contribution of the South Fork Koktuli flows.

THIS IS THE ONLY MENTION OF SIGNIFICANT ERROR AND UNCERTAINTY PERTAINING TO THE DAM BREACH MODELING, AND THE OMISSION OF FURTHER DISCUSSION IMPLIES THAT THE ANALYSIS HAS A REASONABLY HIGH LEVEL OF UNCERTAINTY. THE UNCERTAINTY IN THE ESTIMATION OF THE PEAK FLOWS RESULTING FROM THE TAILINGS DAM BREACH MODELING IS EXTREMELY HIGH. MANY KEY ASSUMPTIONS THAT THE MODEL RESULTS ARE VERY SENSITIVE TO ARE NOT DISCUSSED, INCLUDING THE TOTAL VOLUME OF MATERIAL RELEASED, THE SIZE OF THE DAM BREACH, AND THE RATE OF BREACH DEVELOPMENT, TO NAME A FEW. THEREFORE THE, DAM BREACH MODEL PRESENTED IN THE ASSESSMENT REPORT IS FLAWED, THE REPORTED RESULTS ARE DUBIOUS AND THE CONCLUSIONS ARE UNSUBSTANTIATED. (Doc. #4962, p. 60)

- **4.4.2.4 Tailings Dam Failure via Flooding and Overtopping: 4-50** For comparison, a U.S. Geological Survey (USGS) gage located near the village of Ekwok, Alaska, experienced a record peak flood of 3,313 m^3/s in a 2,551 km^2 watershed. Under the partial volume dam failure, the peak flood is estimated at 1,862 m3/s immediately upstream of the TSF 1 dam, where the watershed area is 1.4 km^2. Thus, on a unit area basis, the tailings dam area in the partial-volume failure analysis would result in a more than 1,000-fold increase in discharge compared to that observed in a record flood; for the full-volume analysis, there would be more than a 6,500-fold increase.

THE ASSESSMENT REPORT USES WATERSHED AREAS THAT ARE INCORRECT. THE WATERSHED AREA FOR THEIR ASSUMED TAILINGS IMPOUNDMENT IS MORE IN THE ORDER OF 14 KM2 THAN 1.4 KM2, AND THE DRAINAGE AREA FOR THE NUSHAGAK RIVER IS 25,550 KM2 RATHER THAN 2,551 K M (USGS PUBLISHED AREA IS 9850 SQ. MILES).

THIS IS A SPURIOUS COMPARISON. PEAK FLOWS TYPICALLY HAVE A NON-LINEAR SCALING RELATIONSHIP, WITH SMALL BASINS IN A REGION HAVING HIGHER UNIT FLOWS THAN LARGE BASINS (CATHCART 2001), SO IT IS NOT VALID TO DIRECTLY COMPARE UNIT PEAKFLOWS FROM THE TAILINGS IMPOUNDMENT AREA WITH THOSE FROM A BASIN THAT IS 1821 TIMES GREATER IN AREA.

ALSO, THE "RECORD PEAK FLOOD" QUOTED IS THE LARGEST EVENT FOR A SIXTEEN YEAR FLOOD RECORD FOR THE NUSHAGAK RIVER AT EKWOK (USGS STATION 15302500), AND HAS A RETURN PERIOD OF BETWEEN 20 AND 25 YEARS. IT IS NOT VALID TO COMPARE THIS FLOW TO A FLOW RESULTING FROM A DAM FAILURE TRIGGERED BY THE PROBABLE MAXIMUM PRECIPITATION, WHICH IS AN EVENTS0 SEVERE AND UNLIKELY THAT THEORETICALLY ONE CANNOT ASSIGN A PROBABILITY TO IT.

FINALLY, PEAKFLOWS VARY SUBSTANTIALLY ACCORDING TO THE CHARACTERISTICS OF THE DRAINAGE BASIN, INCLUDING THE CLIMATE. THE QUOTED RECORD PEAKFLOW IS FOR AN AREA THAT IS RELATIVELY DRY AND FLAT, AND WHEN CORRECTED FOR THE PROPER DRAINAGE AREA, HAS A UNIT RUNOFF OF 0.13 M3 /S/KM2. ANOTHER RIVER IN THE REGION, THE ILIAMNA RIVER, HAS A PEAK FLOW THAT CORRESPONDS TO A UNIT RUNOFF OF 4.5 M3/S/KM2, WHICH IS 35 TIMES GREATER. IT IS NOT VALID TO USE THE FLOWS FROM THE NUSHAGAK RIVER FOR COMPARISON WITHOUT QUALIFICATION. IF THE ILIAMNA RIVER VALUES WERE USED AS THE BASIS OF COMPARISON, WHICH IN ITSELF IS NOT PARTICULARLY VALID, THE 1000-FOLD AND 6500 FOLD INCREASES WOULD REDUCE TO 29-FOLD AND 186-FOLD, RESPECTIVELY. THESE RATIOS ARE STILL VERY LARGE, AS WOULD BE EXPECTED WHEN COMPARING A THEORETICAL PMF DAM BREACH FLOOD WITH A HISTORICAL FLOOD, BUT THEY HAVE FAR LESS SHOCK VALUE THAN THE RATIOS QUOTED IN THE ASSESSMENT REPORT (Doc. #4962, p. 60-61)

- **4.4.4 Road and Culvert Failures: 4-63** The mine access road would traverse varied terrain and subsurface soil conditions, including extensive areas of rock excavation in steep mountainous terrain (Ghaffari et al. 2011). Thus, although the road design, including placement and sizing of culverts, would take into account seasonal drainage and spring runoff requirements, road and culvert failures would be expected. Thus, two of the remaining 16 streams with less than 5.5 km of upstream habitat might be bridged, leave 14 salmonid streams with culverts. Assuming typical maintenance practices after mine operations, roughly 50% of these streams, or 7 streams, would be entirely or partly blocked.

IT IS NOT CLEAR HOW THIS CONCLUSION IS REACHED. PROVIDED THE ROAD CROSSINGS ARE PROPERLY ENGINEERED AND CONSTRUCTED TO APPROPRIATE STANDARDS, ROAD AND CULVERT FAILURES WOULD NOT BE EXPECTED. CULVERTS COMMONLY OPERATE SUCCESSFULLY IN STEEP MOUNTAINOUS TERRAIN. (Doc. #4962, p. 62)

- The current industry standard for the design and installation of conveyance structures (including culverts, bridges, and fords) in fish bearing streams requires maintenance of the physical and biological processes of the subject stream or river. A properly formulated culvert design maintains sediment, debris, and flood flow, and aquatic organism conveyance (both upstream and downstream) similar to that of the natural stream. Design techniques such as the "Stream Simulation" approach have been developed and successfully employed over the past two decades in Alaska, California, and the Pacific Northwest. As many reports have described in detail, this approach incorporates a continuous streambed that mimics the slope, structure, and dimensions of the natural streambed (WDFW 201 1; FHWA 201 0, 2007; CDFG 2009; USDA 2008). Water depths and velocities through and around the conveyance structures are as diverse as those in the natural channel, providing passageways for all aquatic organisms (USDA 2008) and maintaining sediment and debris continuity. Installation of such structures would likely result in less potential impact than assumed in the draft Assessment Report. (Doc. #4962, p. 66)
- **Section 4.4.4 Page 4-62, Last Paragraph**: "Reported culvert failure rates vary throughout the literature but are generally high ...Thus, although the road design, including placement and sizing of culverts, would take into account seasonal drainage and spring runoff requirements, road and culvert failures would be expected." Note: Failure is defined in stated paragraph as: "if the passage of fish is blocked or if streamflow exceeds culvert capacity, thus resulting in washout of the road."

  Response Current design techniques for streams with resident or anadromous fish include evaluating more than "seasonal drainage and spring runoff requirements." Modem standards foster designs that are self-sustaining, durable, and provide continuity of geomorphic processes such as the movement of debris and sediment (CDFG 2009). National Marine Fisheries Service NMFS) design criteria require that all fish passage facilities be designed for the 100-year flood event (2001) and that any potential damage to the crossing be addressed as part of the design process. These design criteria reduce the potential for culvert failure, both from blockage of fish passage and road washout, and promote habitat and fluvial process continuity. (Doc. #4962, p. 69)

- The Assessment is based almost completely on assumptions and hypothetical scenarios; however, every mine is very different in terms of its design and operations. In addition, EPA appears to have focused almost exclusively on past mine failures in its Assessment rather than on mine successes, particularly those currently operating under modern engineering design standards. This approach suggests an inherent bias in EPA's Assessment that undermines its utility and would certainly lead to arbitrary and capricious agency action if the information contained in the Assessment is used in support of future decision-making. Due to the Agency's reliance on uninformed assumptions, disregard for current mine practices and neglecting required mitigation measures, the attached collection of technical papers is intended to serve as a primer on some of the basic principles of current mine development within the regulatory and permitting framework in Alaska. It is clear that EPA lacks that basic understanding. The white paper series therefore has two primary objectives: (1) to share knowledge of key technology issues related to modern mine design and mitigation options; and (2) to provide additional scientific citations for consideration as part of the Assessment. (Doc. #5416, p. 1)

National Mining Association (Doc. #4109.2)

- The Draft Assessment is also filled with unlikely scenarios and assumptions that are not sufficiently placed in proper context. For example, section 5.2 of the Draft Assessment attempts to quantify the impact that development may have on stream-flow rates, but later acknowledges that doing so accurately is not feasible. Similarly, Section 4.4.3.1 makes unrealistic assumptions about the volume of material that could flow from a failed pipeline due to EPA's failure to take into consideration the fact that flow rates reduce during shut downs, thereby reducing the volume of material spilled. (pp. 4-5)

Northern Dynasty Minerals (Doc. #4611, 4611.5, 4611.6, 4611.7 and 4611.8)

- In discussing the possible tailings dam failures, EPA cites Table 4-8 of the Draft Assessment, which identifies 135 tailings dam accidents and failures as relevant to the supposed risk in the hypothetical mine activity that EPA analyzes. Yet, 93% of these incidents (126 of 135 examples), do not involve the type of dam construction that NDM knows is being studied by PLP, making these accidents and failures wholly inappropriate and irrelevant in the present analysis. (Doc. #4611, p. 6)
- NDM is also troubled by the EPA's erroneous assumption that Pebble's tailings embankments will allow only 14 inches of freeboard and that tailings water will be immediately below the bank crest. NDM believes it is more realistic that PLP will design for more than 50 feet of freeboard and that under normal operating conditions, tailings water would be set back approximately 1,000 feet from the embankment crest, consistent with Alaska dam safety permitting requirements. EPA's hypothetical mine would never be permitted given the

assumptions used on this point. (Doc. #4611, p. 6 to 7)

- The tables below can be found on Doc. #4611 p. 25 to26.

Draft Watershed Reference	Commentary
Pg. 4-49, Figure 4-12	The y-axis jumps from 10^{-1} (i.e. 0.1) to 10. The 10 should instead have been 1. This may be a typo, but it is misleading in terms of overestimating probability of failure.
Pg. 4-50: "For comparison, a U.S. Geological Survey (USGS) gage located near the village of Ekwok, Alaska experienced a record peak flood of 3,313 m3/s in a 2,551 km2 watershed."	It is unclear which USGS gage was used, but the mean daily flow data from the USGS gage on the Nushagak River at Ekwok, AK (15302500) was acquired from October 1, 1977 to September 30, 1993. The maximum daily flow during this period was 3,228 m^3/s and the drainage area associated with this gage is 9,850 mi^2 (3,449 km^2). Using this information on a unit area basis (110 $m^3/s/km^2$ for partial release and 701 $m^3/s/km^2$ for full release) the partial volume failure analysis would result in 117-fold increase (not 1,000-fold) in discharge compared to flow observed at the USGS gage and for the full volume failure analysis, there would be a 750-fold increase (not 6,500-fold). The Draft Assessment overstated the increase in flow by almost one order of magnitude, i.e. almost 10 times.
Pg. 4-53, Box 4-8: "HEC-RAS inputs included geometry of an inline structure to simulate the dam cross-section and stream channel geometry data, both derived from a 30-m digital elevation model"	Per the HEC-RAS manual (USACE, 2010), if an analysis is completed using bathymetric cross sections developed from a 10 meter DEM or coarser are used "then you should not expect to be able to get good model calibration with such poor terrain data." This significant shortcoming and misuse of HEC-RAS is not acknowledged in the Draft Assessment
Pg. 4-60: "The failure rate from third-party impacts, such as damage caused by excavating equipment, tends to be steady over time, whereas corrosion failures tend to increase with age of the pipe."	This statement directly contradicts the subsequent statistical analysis and development of an annual probability of pipeline failures, which has an implied assumption of constant failure rate.

Draft Watershed Reference	Commentary
Pg. 4-62: "Distance to nearest shutoff valve of 14 km. This value assumes there would be isolation valves capable of being remotely activated on either side of nine major river crossings along the transportation corridor. This is similar to the plan laid out in Ghaffari et al. (2011), although they call for manual rather than automatic isolation valves."	On the contrary, Wardrop (2011) (i.e., Ghaffari et al., 2011) states that "manual isolation valves are provided on either side of "major" river crossings" (pg. 337). There is no basis for the nearest shutoff valve being 14 km away. Wardrop (2011) characterizes major river crossings as 600 feet across.
Pg. 4-53, Box 4-8: "Tailings dam failure via overtopping is expected to have similar effects as failures resulting from other causes (e.g., slope failure, earthquakes)."	Mine tailings outflow volume and runout distance is always affected by the mode of failure.
Pg. 4-57, Box 4-9: "We assumed that sediment deposition could occur in the channel and the floodplain of each section at the maximum predicted channel depth during the peak of the flood wave."	When river flows are at their maximum flood stage, river velocities are often at their highest, which is not conducive to sediment deposition. As such, this EPA assumption is not correct.
Pg. 4-57, Box 4-9: "We assume a particle size distribution of 0.1- to 1.0-m diameter for the dam construction material, and less than 0.01- to just over 1.0-mm diameter for the impounded tailings material (Figure 4-13). Based on the Hjulstrom curve—which estimates when a stream or river will erode, transport, or deposit sediment based on flow speed and sediment grain size—all of the mobilized tailings would remain in suspension at water velocities greater than 0.05 m/s (0.16 feet/s)."	The Hjulstrom curve was developed based on particles 5 mm and larger while the tailings particle sizes are assumed to range from less than 0.01 mm to just over 1.0 mm. This curve is not applicable to evaluate sediment transport following a dam breach.
Pg. 5-41: "In the upper reaches of the North Fork Koktuli River (upstream of NK119A), the mainstem and tributaries would experience direct loss of habitat to the mine footprint or substantial loss in flow (73% reduction at gage NK119A). Downstream of gage NK119A, flow reductions of 15%, 7%, and 5% at gages NK100B, NK100A1, and NK100A respectively, would be expected (Table 5-6)."	As indicated on **pg. 5-24, Table 5-6**, this paragraph overstates Net Flow Reductions (%) as follows: NK119A = 63% (less than 73%) NK100B = 13% (less than 15%) NK100A1 = 6% (less than 7%)
Pg. 5-61: "Standards for culvert installation on fish-bearing streams in Alaska target road safety and fish passage, but not the physical structure of the stream or habitat quality (ADFG and ADOT&PF 2001)."	The reference cited to support this statement (ADFG and ADOT&PF 2001) is the culvert design standard itself rather than a reference that supports the statement. The standard contains several provisions targeted at stream stability and habitat quality which makes the EPA statement incorrect.

- The Assessment contains numerous fatally flawed errors in their modeling assumptions with respect to mine operations and the failure scenario, resulting in fatally flawed conclusions regarding mine water balance and impacts to salmon resources downstream of the TSF 1 site. The Assessment provides insufficient detail on the failure scenario modeling that would allow the reader to determine if the impacts as described are "realistic". Critical missing information includes assumptions regarding flood routing, cross sectional information used to develop the depositional profiles presented, an explanation of the physics of why and how the North Fork Koktuli channel could scour to bedrock given that the water passing over is fully saturated with tailings particles, and any model information downstream of the confluence of the North and South Koktuli rivers resulting in unsupported speculation about downstream deposition and a scientifically indefensible conclusion about impacts to Chinook salmon populations in the Nushagak watershed. (Doc. #4611.5, p. 8 to 9)

- The Assessment page 4-45: Section 4.4.2.2 Probability of Tailings Dam Failures and Table 4-8. The Assessment presents information on the probability of tailings dam failures in this section and in Table 4-8. However, the reader is provided with no scientifically defensible information, data, or analysis to demonstrate that the probabilities of failure presented in the Assessment come from tailings dams that are comparable with the type of dam structure assumed by EPA in the mine development scenario. The Assessment should only present failure rates for dams that are constructed essentially identical to that envisioned in the development scenario. Inclusion of any dams built with different engineering designs or construction and maintenance standards should not be presented in the Assessment. What is needed is an "apples to apples" comparison in order to provide a meaningful comparison. The Assessment does not provide a valid or defensible analysis on this topic. (Doc. #4611.5, p. 24)
- The Assessment page 4-60: Section 4.4.3.1 Causes and Probabilities of Pipeline Failures. This entire section of the Assessment is fraught with problems. First, why was the failure rate data from the oil and gas industry used instead of information from the mining industry? Second, is the failure rate of all of the pipelines reviewed in Table 4-14 comparable to the conditions, level of inspection and maintenance, and construction standards that will be applied to the mine development scenario? Finally, is the content of the pipeline responsible for what percentage of the problems that result in pipeline failure? Failure of the Trans Alaska Oil Pipeline was due to corrosion caused by the substance being transported and improper inspection and maintenance. So how could data on this pipeline failure be comparable to what would be expected under the mine development and operations scenario in the Assessment? The Assessment fails to present any credible documentation or analysis that demonstrates to the reader that the selection of pipeline failure rates from the oil and gas industry will be comparable to the mining industry. The Assessment needs to be rewritten using scientifically valid and defensible data and analysis that supports the selection of the probability of failure rate for pipelines carrying the materials outlined in the mine development scenario and receiving the inspection and maintenance anticipated in the Assessment. The current conclusions in the Assessment are not supported by a scientifically defensible methodology, selection of data, or analysis to reach the conclusion regarding pipeline failure rates. (Doc. #4611.5, p. 24 to 25)
- The Assessment page 4-62: Section 4.4.4 Road and Culvert Failures. This entire section of the Assessment is based on a lack of knowledge of the fish passage requirements for salmonid fishes in relation to modern mine road construction and maintenance. In addition, this section fails to mention the fish passage requirements imposed by the Alaska Department of Fish and Game on any project like the proposed mine development scenario. The use of

Furness et al, (1991) as a primary reference on the impacts of road construction on streams is a completely inappropriate and scientifically indefensible, since Furness et al. (1991) reviewed mostly temporary roads constructed in the 1950s to 1970s in the Pacific Northwest. These were mostly temporary access roads to support timber harvest and did not have the design standards or road maintenance requirements that a current day industrial grade mining road would have. The use of this reference alone demonstrates the complete lack of knowledge and ignorance by EPA about modern road design and maintenance requirements. Also, the Assessment asserts that Warren and Pardew (1998) conclude that "Culverts are deemed to have failed if the passage of fish is blocked or if stream flow exceeds culvert capacity, thus resulting in washout of the road (Warren and Pardew 1998, Wellman et al. 2000)". However, review of Warren and Pardew revealed that they make no such claim in their report. Also, the use of Warren and Pardew as a reference is scientifically invalid, since they tested fish passage on small-streams in Central Arkansas, using fish from the sunfish, minnow, and killifish families as their primary test subjects, not salmonid species found in the watersheds of the Assessment. This reference does not constitute a scientifically valid assessment of the effects of culverts in the Pebble project area or along the hypothesized transportation corridor as described in the Assessment. The impacts outlined in this section again come from Furness et al. (1991) and are completely invalid. The Assessment fails to meet EPA's own standards regarding ecological risk assessment and data quality. The Assessment needs to be rewritten to professionally and comprehensively present a scientifically defensible and professionally credible description and analysis of the effects of road crossings on streams along the hypothetical road corridor and based on modern mine road design and maintenance. The current description and conclusions based on what's in the Assessment are totally invalid. (Doc. #4611.5, p. 25)

- The Assessment on pages 5-59 and 5-60: Section 5.4.1 Culverts; states: "Culverts are the most common migration barriers associated with road networks. Hydraulic characteristics and culvert configuration can impede or prevent fish passage. Where flow restrictions such as culverts are placed in stream channels, the power of stream flow is increased. This can lead to increased channel scouring and down-cutting, stream bank erosion, and undermining of the stream crossing structure and fill. Although the well planned installation of culverts allows natural flow upstream and downstream of crossings, failure rates are generally high (Sections 4.4.3.3 and 6.4)."
  Comment: The implications of the paragraph quoted above are that culverts have the potential to cause channel changes and impede or block fish passage. It also indicates that "…well planned installation of culverts allows natural flow upstream and downstream of crossings …", which indicates that if a culvert is properly sized, installed, and maintained that few changes in the channel or impacts to fish passage can be anticipated. However, the paragraph also indicates that "… failure rates are generally high (Sections 4.4.3.3 and 6.4)". The paragraph refers to two sections of the Assessment to support the conclusion regarding culvert failure rate. First, the Assessment contains no Section 4.4.3.3, so for this comment it is assumed that the authors are referring to Section 4.4.4. Review of Sections 4.4.4 and 6.4 reveal that the Assessment has used inappropriate data and references to support the culvert failure rates shown in Sections 4.4.4 and 6.4 and calculation of culvert failure rates presented in Box 8-1 and Table 8-1.
  Section 4.4.4 describes the problems associated with culverts and cites Furness et al. (1991) among others. What EPA failed to understand is that Furness et al. (1991) assessed

temporary roads constructed in the 1950s to 1970s for land management activities in the Pacific Northwest. These roads were often placed in locations designed to access timber sales with little regard for slope stability, proper culvert placement and design, proximity to waterways, or maintenance needs. In fact, some of these roads never received maintenance, except for an occasional grading to smooth out the ruts. This reference is not applicable to a modern mine road alignment and design criteria, especially in Alaska where protection of fish bearing streams is a constitutional requirement.

The references with respect to culvert failure rates are also inappropriate for this Assessment. The title of the Gibson et al. (2005) paper is Loss of fish habitat as a consequence of inappropriately constructed stream crossings, which in itself describes the outcome of their evaluation, because the culverts were not installed correctly. In fact, only two of the 47 culverts evaluated were of a "squash pipe" design which allows a natural stream bottom to be established and the remaining 45 culverts were straight pipes with a majority not being properly seated into the stream bottom according to agency requirements. Price et al. (2010) report a 30% failure rate 34 among the 77 culverts examined. However, Price et al. (2010) clearly state: "Our results indicated the 30% of culverts (23 of 77) permitted under the HPA process for fish passage were, in fact, barriers. Culverts permitted as no-slope (one of the most common design types) or as an unknown design type were barriers in 45% of cases. Most culvert failures were due to noncompliance with permit provisions, particularly culvert slope, and a lack of critical evaluation of proposed plans in the context of site conditions by permitting biologists."[Emphasis added]. Again, the primary factor in culverts being rated a failure was not because a culvert was installed as a crossing structure, but that it was not installed according to agency guidelines or the permitting biologist did not critically evaluate the proposed plans.

Flanders and Cariello (2000) report failure rates of 66% for anadromous culverts and 85% for non-anadromous culverts on roads constructed on the Tongass National Forest in Southeast Alaska. However, careful review of the criteria used to determine whether fish passage was achieved reveals a high standard of passage (i.e., weakest swimming juvenile fish able to pass under all flow conditions). In addition, Flanders and Cariello (2000) outline the conditions that caused a culvert to not meet the passage criteria established (see the passage criteria and conditions immediately below).

> *"Adequate fish passage requires that the weakest swimming fish present in a watershed can pass upstream and downstream through culverts at all flow levels when that species would be likely to pass the same point in the stream, absent the culvert. The above results rely heavily on assumptions regarding swimming capability of juvenile fish and estimated stream flow. While some culverts may be complete barriers to both adults or juveniles, many of the culverts on anadromous streams identified in this report as assumed not to be adequate for fish passage most likely only restrict the movement of juvenile salmonid fish.*
>
> *Velocity is the most common cause of fish passage restriction in culverts. If a culvert is installed at too steep a gradient or the culvert width is significantly narrower than the streambed width, the water velocity will be increased within the culvert. Very slight changes in the slope of the culvert and the roughness of the substrate within the culvert may significantly change velocity and the ability of fish to pass through the culvert during all of the times of year when they normally move upstream or downstream. Other frequent causes of fish passage problems include perching of the culvert outlet above the*

water surface, blockage by excessive substrate or woody debris within the culvert and structural damage to the culvert. In most cases, multiple factors interact to restrict fish passage."

What Flanders and Cariello (2000) really documented was improper design, installation, and maintenance not the fact that a culvert was used as a crossing technique.

The Assessment is fatally and fundamentally flawed in its conclusions regarding the use of culverts and culvert failure rates for several reasons. First, the Assessment used inappropriate literature to quantify culvert failure rates. The results from the references cited all point out quite clearly that improper design or installation of culverts can be the major source of culvert failure or blockage of fish passage. Why didn't the Assessment use culvert failure rates for mining 35 roads constructed and maintained in Alaska, such as Red Dog, Pogo, or Fort Knox? These mines alone have over 105 miles of modern, all-weather road that are used and maintained essentially the same as hypothesized in the routine operations scenario. Second, it is unreasonable for the Assessment to use these references since the assumption for the routine operations scenario is that the transportation corridor would be constructed according to standard engineering practices, appropriate functional mitigation measures, in accordance with state and federal requirements, vigilant inspections during construction to ensure proper installations, and routine daily maintenance inspections. All of these measures would eliminate most of the reasons cited in these references that caused the culvert failures documented. The assertions in Section 6.4.1 regarding failure rates is nothing but scientifically indefensible speculation and simply does not reflect reality. Third, EPA clearly lacks an understanding of the importance of maintaining a fully functional transportation corridor to a large scale mining operation. That corridor is transporting potentially millions of dollars of product and critical operational supplies daily and any disruption of the pipelines or road access is simply not an acceptable situation and repairs or remediation would occur immediately. Fourth, the entire discussion of road and culvert failures in the Assessment in Sections 4.4.4, 5.4, 6.4, and Chapter 8 are based on the use of inappropriate literature, invalid comparisons between the locations and situations evaluated in the literature cited and the hypothetical transportation corridor outlined in the Assessment, and highly speculative and in some cases just plain wrong (e.g., the conclusion in Section 6.4.1 that multiple culvert failures could result in closure of the transportation corridor for "more than a month") assumptions and conclusions that are scientifically indefensible. Finally, the Assessment, by using inappropriate data and references and scientifically indefensible assumptions and conclusion clearly failed to meet EPA's ecological risk assessment and information quality guidelines with respect to data quality, appropriateness of the data and literature used, and disseminating high quality and science based information to the public. The Assessment fails to meet EPA's own standards of scientific quality and professionalism for the products they produce. This Assessment is replete with examples of the same type of problems in many other topic areas, but this is one of the most egregious examples found so far. (Doc. #4611.5, p. 38-40)

- 4-44 Table 4-7 Conspicuous by its absence in this table is the double earthquake that occurred on October 23 (6.7 magnitude) and November 3 (7.9 magnitude; ~2 min duration) 2002 along the Denali fault south of Fairbanks, AK. This pair of seismic events is very relevant to any seismic evaluation of tailings embankments in Alaska because of its close proximity to the Fort Knox Mine tailings and water reservoir embankments and the very detailed data that were collected from seepage monitoring wells and vibrating wire piezometers installed within the embankments for monitoring purposes. After the first event, vibrating wire piezometers and seepage flows were monitored on a daily basis (Gillespie 2002). Enhanced monitoring at the tailings embankment and the water reservoir embankment downstream continued for several weeks after the second event. Inspections revealed no signs of movement, slope or crest deformation or settlement associated with either embankment. Seepage monitored at both embankments remained clear throughout the enhanced monitoring period and beyond and no signs of piping were observed. No changes in suspended solids or other parameters occurred in monitoring wells near interceptor wells below the tailings facility, indicating no change in groundwater flow (Gillespie 2002). All this information is readily available and has been since December 2002. The bottom line is this: in spite of a double seismic event of 6.7 and 7.9 magnitude close to a modern tailings embankment, enhanced monitoring of a suite of critical parameters revealed that nothing happened. In other words, the facility behaved as designed. Omission of this important information, which is directly related to the assessment of seismicity and tailings embankment stability, and reflective of performance of a relatively modern mining facility, built and operated in Alaska, is a serious failure of EPA when engaging in a comprehensive and realistic analysis. This is a serious omission bordering on negligence, and imparts a significant bias to the assessment. (Doc. #4611.6, p. 10)

- 4-53 Box 4-8 This box makes the important point that the "headwaters" location of the assumed TSF mitigates against a large Probable Maximum Flood (PMF). It also states that "[i]f sufficient freeboard is maintained, it would be possible to capture and retain the expected volume of the PMF in the TSF." An important additional point, that EPA failed to present, in their description of the full TSF failure scenario is that the amount of watershed available to contribute to a PMF (sloping toward the TSF) in this scenario is essentially the surface area of the TSF itself. This makes it even more unreasonable to assume that insufficient freeboard would be maintained in the full TSF scenario; even a probable maximum precipitation event (PMP) such as that presented by EPA would not add much to the water surface elevation in the TSF. Strangely, EPA does not disclose what the water surface elevation increase for either the Full TSF or the Partial TSF failure scenario would be; it should have. Furthermore, this box fails to disclose that the State of Alaska requires that sufficient freeboard be maintained in all tailings storage facilities to retain far more than the PMF, plus a sizable safety margin on top of that. The box goes on to say that "to examine potential downstream effects in the event of a tailings dam failure, we assume that sufficient freeboard would not exist and overtopping would occur," in spite of monitoring and maintenance. In other words, EPA is forced to make an unreasonable assumption in order to have something to analyze. This is a significant departure from EPA's own promise to develop a reasonable analysis. (Doc. #4611.6, p. 10)
- 4-50 §3 ff. Tailings Dam Failure via Flooding and Overtopping – The "full-volume failure" TSF embankment failure is unrealistic and unreasonable in the extreme and on several levels. First, there is very little watershed surrounding the TSF to contribute to a PMF; the available watershed is a fraction of the surface area of the TSF itself. Second, given the precipitation model presented later in the report in Table 4-7, the total water contribution to the TSF from direct precipitation is 0.36 m (a little over 1 ft). A reasonable contribution from the available surrounding watershed added to direct precipitation might bring the water surface elevation up as much as 0.5 m (a little over 1.5 ft). To assume that any mine operator or oversight agency would let freeboard fall to this level is completely unreasonable. Tailings

impoundments operate by pumping a slurry from the mill through spigots to form beaches, primarily adjacent to embankments, and pumping water back to the mill from a deep portion of the pond. Beaches extend long distances from the spigots, often miles. Water depth over the great majority of the impoundment is either zero (in the areas occupied by beaches) or shallow. The EPA full TSF scenario would unreasonably assume no freeboard represented by tailings beaches adjacent to the embankment. This freeboard, along with the portion of the embankment crest supporting spigots and piping would alone provide sufficient freeboard to capture the PMF at this site. Curiously, EPA never tells the reader how much water surface elevation gain would be produced by the PMF, an important factor in evaluating the reasonableness of the analysis. It should be in the analysis.

Perhaps most important, however, is the assumed location of the breach in EPA's "full-volume failure" scenario. Once the elevation of the saddle between NK 1.190 and SK 1.190 is reached by the northern embankment of TFS-1, it is unreasonable in the extreme to assume that the southern embankment would ever be allowed to be as high as the northern embankment, where freeboard is an issue. No rational mine operator would allow this to occur, and no rational regulator would, either. The safety value of a "freeze-plug" at the southern embankment, by keeping it at a slightly lower elevation, is much too great. The only logical, albeit still unreasonable, full-volume scenario is to have the failure occur at the southern embankment. The elevation of the saddle between the two watersheds containing TSF-1 is 468 m MSL. The elevation of the northern embankment crest at full status would be ~558 m MSL. The difference between the elevation of the saddle, which would serve as a control in the event of a failure, is ~90 m. Therefore, the only logical, if still unreasonable, failure would involve about 90 m (vertical) of tailings, crest to control, not 208 m. Thus, the "full-volume failure" scenario would be of lesser magnitude than the "partialvolume failure" scenario, and would be directed toward the South Fork Koktuli River, not the North Fork. Given the topography at the mouth of SK 1.190, most of the volume of material that would exit the TSF would be directed upstream (east) onto the "South Fork Flats", with some material moving downstream through the narrower valley constriction to the west.

The bottom line is that the "full-volume failure" scenario offered by EPA is not well thought out and unreasonable on several fronts. It fails to consider the relationship between the minor water surface elevation gain produced by the PMF and any reasonable freeboard; it fails to consider the freeboard required for routine operation and maintenance with respect to common wind wave generation, among other factors; it vastly overestimates the volume and average depth of the decant pond prior to overtopping and assumes an unreasonable operating condition; and it fails to consider the strategic maintenance of a lower crest elevation at the south embankment than the north embankment, with the result that the least unreasonable failure would be directed primarily onto the South Fork Flats. For all these reasons, the EPA's "full-volume" TSF failure is unreasonable and not credible. (Doc. #4611.6, p. 11)

- 4-56 §3 This paragraph states, "over 70% of the released tailings are modeled to remain in suspension at the 30-km model endpoint, indicating that effects would actually extend far beyond the 30-km reach." Given the valley land form and cross-sections at the 30-km reach and the stated depth of deposit, this does not appear to be possible. As stated in the next comment, the entire tailings mass could be deposited several times over in a reach between Station 0.6 and Station 9.4 on the North Fork Koktuli assuming deposit depths given in Table 4-13 and flood routing to available low-velocity areas (see next comment). Either 70% of the tailings would remain in suspension and the depths of deposits along the North Fork Koktuli (and South Fork Koktuli, which was strangely excluded from the model) would be a very small fraction of that estimated by EPA's model, or nearly all of the tailings would settle out in the available North Fork and South Fork flood plains at or before the confluence of the North Fork Koktuli with the South Fork, with very little left to transport. EPA cannot have it both ways. This is an obvious failure of the approach taken by EPA to assess the consequences of an unreasonable if hypothetical failure of a hypothetical TSF. The outcome of this modeling exercise should be completely disregarded until the modeling approach is evaluated and calibrated by a qualified outside expert and tested against actual valley cross-sectional profiles with rational flood routing, including up the South Fork Koktuli flood plain. In addition, any assumed impacts relying on this modeling exercise should be disregarded as resting on a faulty foundation. (Doc. #4611.6, p. 12)

- 4-59 Table 4-13 The sediment deposit depths and cross-sectional area values in this table are preposterous, especially in light of the EPA assertion made in the text that 70% of the ~300 million m3 of material from the TSF remains in suspension past the modeled reach (past the confluence of the North Fork Koktuli and the South Fork). Regardless of the model output, a depth of deposition of tailings in the full TSF scenario of 14m at Station 0.6 km would result in a crosssection of deposition far greater than given in the table.
  The channel elevation of the North Fork Koktuli stream bottom at Station 0.6 is approximately 182 m MSL. For a deposition depth of 14 m, the water surface elevation would have to be at least 194 m or higher, assuming this depth of deposit was at the channel bottom, which it could not be, given EPA's velocities. If deposits of this depth were at some lateral distance from the channel bottom, the top of a 14 m deep deposit would have to be at a correspondingly higher elevation. At an elevation of 194 m (the lowest possible albeit unrealistic elevation), the valley flood plain available for deposition is in excess of 4 km, and includes the flood plain of the South Fork. Along a transect at right angles to the valley at this point, the flood plain profile is the shape of a saucer, with a maximum elevation of about 1 m separating the North Fork Koktuli from the South Fork, and with much more than half the product of length and height available for deposition. Given the depth of deposition in Table 4.13 (14 m), the cross-sectional area given in the table of 3,635 m2 is inconsistent with a saucer-shaped flood plain >4 km across. In the EPA scenario, the South Fork Koktuli would be backwatered, and its entire flood plain would be available for deposition. In reality, an actual cross section at Station 0.6 would easily be capable of receiving >35,000 m3 of deposited material per lineal m of valley bottom to an elevation of 194 m MSL.
  At Station 5.4, the North Fork Koktuli River channel bottom is at elevation ~197 m. According to Table 4-13, deposition would be to a depth of 8.1 m higher than the ground elevation in the deposition area, which would have to be significantly higher than the channel bottom. This would result in a water surface elevation well in excess of 205 m MSL. At this (unrealistically low) elevation, the flood plain available for deposition is in excess of 5.3 km, and again includes the flood plain of the South Fork Koktuli. In spite of a "hump" in the middle of a transect (still considerably lower than flood water elevation) at this station, there is far more sediment storage available in the South Fork Koktuli, which is 9 m lower in elevation than the North Fork in this area, and has a broad, flat profile. Given these relative elevations, flood waters would be routed south to and up the South Fork a distance of at least 11 km, which was not included in the model. Easily more than half the product of length and height along a transect at this station is available for sediment deposition, or >21,400 m3 per

lineal m of valley bottom, which is inconsistent with the depositional cross-sectional area of 4,857 m2 given in the table.

Finally, at Station 9.4, the channel bottom is at elevation ~213 m MSL. According to Table 4-13, maximum depth of deposition would be nearly 9 m, requiring a water depth to elevation well in excess of 222 m MSL. A transect across the flood plain available for deposition at this station would have a length in excess of 6.6 km and, again, would include the South Fork, which was not included in the model. Along this transect, the South Fork Koktuli channel is more than 10 m lower in elevation and the associated local flood plain contains vastly more sediment storage and flood water routing capacity than the North Fork. Obviously, a significant proportion of the flood wave would be routed into the South Fork Koktuli flood plain, especially since the stream in that area would have trivial flow compared to the hypothetical flood. In this area, about half the product of the lowest possible elevation transect length and height would be available for sedimentation, or >25,000 m3 per lineal m of valley bottom. EPA neglects to give elevations of the flood crest at each of the stations, making further evaluation of routing difficult, but even without these elevations, it is obvious that routing to the South Fork Koktuli flood plain would occur. This is extremely important information, and EPA was remiss in omitting it from the document. In addition, maps of major sediment deposit areas, at least those associated with the "example" stations along the North Fork Koktuli should have been included in the document. In any event, given the available low elevation flood plain profiles in the lower North Fork and South Fork Koktuli Rivers and obvious routing to the South Fork, there is ample storage capacity away from the main North Fork channel to store the entire mass emanating from the TSF several times over.

Another shortcoming of the EPA modeling exercise is the failure to account for flood water routing upstream on the North Fork Koktuli. According to sediment depths given in Table 4-13, water surface elevations over the North Fork Koktuli channel at Station 30.0 would be at least 333 m MSL. This would produce a backwatering of the North Fork Koktuli for a distance of ~5.5 km (as the crow flies), with an average backwater width of ~2.2 km, and would inundate Big Wiggly Lake. This flood routing and associated sediment deposition capacity is significant and should have been included in the EPA model, as well as flood routing up the South Fork Koktuli for a distance of >11 km.

These facts call the entire EPA modeling exercise into serious question. It is likely that unrealistic parameters were entered into the model, and that the surrounding landform was ignored when the model was run. In any event, EPA must explain what cross-sectional profiles for the North Fork Koktuli, including the backwatering upstream as well as flood routing up the South Fork Koktuli were used and what assumptions were made regarding the deposition of tailings in the available valley bottom flood plain. In addition, all of the assumed impacts based on this model's output are cast into serious doubt, and should be regarded very skeptically or disregarded completely until the model is fully explained and independently validated. That EPA itself did not catch any of these errors is astonishing. (Doc. #4611.6, p. 11 to 13)

- 4-60 §1 This paragraph states, "the remaining tailings in the breached TSF, would serve as concentrated sources of easily transportable, potentially toxic material." This statement assumes that no effort would be expended to repair and remediate the tailings embankment rupture, should it occur. This is an unreasonable assumption. (Doc. #4611.6, p. 13)
- 4-62 §8 – 4-63 §1 The data regarding culvert failure in this paragraph is based on studies of logging roads (primarily) built to 50+ year old standards and generally intended to be

temporary access. Earlier in the document, the assessment assumes an all-weather, permanent industrial road with daily maintenance. Given the earlier assumption, these data are irrelevant. EPA should have used failure frequency data for hundreds of miles of modern, all-weather, permanent, well-maintained industrial roads in Alaska for its analysis. For example, the Red Dog Mine haul road is a 51+ mile long gravel road from the mine to the coast with many culverts, some very large. There have been no culvert failures (e.g. blockages or wash-outs) in its 23 years of operations (Ott 2012, pers. comm.). The Pogo Mine haul road is 49 miles long with 17 culverts. Although in operation for only a few years, there have been no culvert failures. There are many other examples, including the North Slope Haul Road. Information of this kind is readily available and should have been accessed and used by EPA instead of the agency apparently relying on a literature search focusing on old information related primarily to logging road culvert failures and other poorly designed systems with little or no monitoring and maintenance. Conclusions regarding impacts or failure frequencies for the transportation corridor in this EPA analysis based on these data are likewise irrelevant and meaningless in the context of this analysis, and should be disregarded until the text is corrected according to this comment. (Doc. #4611.6, p. 13)

- In their assessment of potential impacts of a tailings dam failure, the EPA Report authors use an overly simplistic model and exaggerate potential fish and fish habitat loss projections. The model (HEC-RAS) used to model potential tailings dam failures in the EPA Report is a one dimensional model, and may therefore not provide accurate results in a three-dimensional environment, such as the Bristol Bay watershed. Further, the EPA Report assumes that, following a tailings dam failure, a1l Chinook salmon will lose access to the South Fork Koktuli and potentially Mulchatna and Stuyahok Rivers; however, the results of modeling do not support this conclusion, and it is likely that any physical blockage resulting from a tailings dam failure would be temporary. (Doc. #4116.7, p. 27)
- The greatest criticism in this section is surrounding statements about fish access to streams due to sediment transport effects. The authors assume that Chinook salmon will lose access to the South Fork Koktuli, and they say that the deposited tailings material may be deep enough to impede fish access to the Mulchatna and Stuyahok Rivers. These conclusions cannot be supported with the results of modeling or any other available data. It seems unlikely this will be the case as these rivers would likely be temporarily dammed by tailings/debris after water from the TSF dam failure recedes. After these rivers become backed up, it is expected that the temporary dams at their mouths would burst within hours or days, thereby removing much of the material that had been blocking the confluence. (Doc. #4116.7, p. 28)
- In another instance (p. 4-57), the text states "Based on historical tailings dam failure data, it is reasonable to assume that all construction material from the dam break and from 30 to 60% of the impoundment tailings material could contribute to debris flow following a tailings dam failure (Browne 2011)'" however, the impoundment tailings proportion values provided in Browne (2011) are "13 to 60%", which indicates a misuse of information by the EPA. (Doc. #4116.7, p. 31)
- The impacts of potential tailings dam failure(s) on Bristol Bay salmon and their ecosystems will be highly dependent on the magnitude, frequency, and timing (e.g., stage in salmonid life cycle, natural seasonal flows) of the event(s), and the baseline resiliency of the affected populations and ecosystems. Based on the demonstrated ability of salmon and their ecosystems to be resilient to catastrophic disturbances, it is possible that they would be able

to recover from a tailings dam failure. Further, the high degree of habitat heterogeneity of the Bristol Bay watershed may provide increased recovery opportunities for aquatic organisms by providing refuges for salmon during disturbance events. Bristol Bay sockeye are known for having high resilience due to the within-stock diversity of life history strategies in the region; this has been exemplified in recent history through shifts in high production between life history- and regionally- diverse populations (Hilborn et al. 2003). (Doc. #4116.7,p. 49)

- The case studies summarized in this report demonstrate that physical disturbances can be overcome by salmon and their ecosystems. However, none of these examples explore the impact of contamination and toxicity effects of catastrophic disturbances as this was not within the scope of this report. Such effects are critical to the discussion of the potential impacts of a catastrophic tailings dam failure and other mining-related accidents or malfunctions. Moreover, case studies excmplify4ng the non-recovery of salmon and their ecosystems from catastrophic disturbances were beyond the scope of this report. Further studies that consider this information should be conducted before a well-informed comparison between the effects of natural vs. anthropogenic disturbances (e.g., the EPA Report's tailings dam failure scenario) can be made. (Doc. #4116.7, p. 50)
- Despite the impression from the BBWA that failure of the TSFs at the Pebble Project appears inevitable, each of these potential failure modes can be mitigated through a combination of proper site investigation, design, construction, operations, and maintenance. For example, overtopping can be mitigated through evaluation of the probable maximum flood (PMF) and consideration of the construction and operation sequencing of the tailings storage facility (TSF) to ensure sufficient freeboard is provided. Foundation failure can be mitigated through proper investigation of foundation conditions and subsequent preparation of a competent subgrade, including removal of poor quality materials, prior to constructing the overlying the dam. In the case of mine subsidence, location of the TSF at sufficient distance from the mine excavations is sufficient to mitigate. However, none of these mitigation strategies are evaluated in the BBWA. (Doc. #4611.8, p. 10)
- Notwithstanding the high standards that are anticipated for the design of the Pebble TSF, Box 4-4 of the BBWA presents four examples of historical tailings dam failures that led to significant release of tailings. These case histories are presented to inform the reader of the likelihood of and the potential implications of a significant tailings release. The sections that follow will present each of those cases, and demonstrate how they are either not relevant to the proposed Pebble Project, or how the failure modes can be readily mitigated at Pebble through proper design, construction, operations and management.
  The tailings dam at the Los Frailes Mine in Spain failed in 1998 primarily due to foundation instability of clays with low residual shear strength. This foundation failure mode can be mitigated for the Pebble TSFs through proper investigation and foundation preparation. As stated in Wardrop (2011): "Embankment foundations will be prepared by removing all organics and unsuitable materials prior to controlled rockfill placement on competent overburden and/or bedrock foundations."
  Two tailings dams failed at Stava, Italy in 1985. The dams were constructed with cycloned sand tailings which separate the coarse and finer fractions of tailings solids. The coarser fraction of tailings was sent to the face of the embankment for staged construction using the upstream2 method of construction. The two dams were built with overly steep embankments, and the toe of the upper dam was supported on the tailings of the lower impoundment. The stability of this configuration had a very low factor of safety against failure. This slope

instability failure mode can be mitigated for the Pebble TSFs through proper investigation and material characterization, and subsequent stability evaluation as input to design. The typical minimum factor of safety under static conditions (i.e. non-seismic) for a modern dam is 1.5, indicating that the forces resisting a slope failure exceed the forces driving failure (e.g. gravity) by 50%. While specific stability analyses have not been reviewed, for Pebble it is likely that seismic criteria will decide the final dam configuration, and static factors of safety will likely be higher than 1.5. Had the Stava tailings dams been designed with appropriate factors of safety, the 1985 failure would not have occurred. As noted in the Wardrop (2011) report, the Pebble TSFs are likely to be built using earth and rockfill as opposed to tailings, and the downstream and centerline methods of construction will be employed instead of the upstream method used at Stava, which is more prone to failure (Wise, 2012).

The Aurul tailings dam failure in 2000 was a result of overtopping of the dams and subsequent breach and tailings release. The overtopping failure mode would be mitigated for the Pebble TSFs primarily through design and operations with sufficient freeboard for extreme events. As stated in Wardrop (2011): "The TSF impoundment is sized to provide additional freeboard for complete containment of all runoff from the inflow design flood, for wave run-up protection, and for any post-seismic embankment settlement." In addition, the TSF embankment is to be constructed of erosion resistant rockfill, which is much less susceptible to failure from overtopping than the Aurul dam which was constructed of cycloned tailings.

The TVA Kingston tailings dam failure in 2008 had many contributing factors, but can primarily be attributed to poor foundation conditions and slope instability. These failure modes would be mitigated for the Pebble TSFs through proper investigation and material characterization, and subsequent stability evaluation as input to design. Additionally, proper foundation preparation and use of downstream and centerline construction are anticipated to result in adequate factors of safety. (Doc. #4611.8, p. 11 to 13)

- Perhaps the most widely quoted reference in relation to the historical record of tailings dam failures is the 2001 ICOLD report which documents accidents and failures at 220 tailings dams3 reported between 1917 and 2000. In the BBWA, after removing accidents that did not result in a failure with tailings release, Table 4-8 presents a tabulation of 135 TSF failures from the ICOLD database, subdivided based on failure cause and whether the failure occurred on an active or inactive tailings dam. Beyond this basic tabulation, no significant attempt is made in the BBWA to interpret the implications of these failure case histories on the hypothetical mine scenario. Only the total number of failures is used when evaluating probabilities of failure. As such, it is questionable whether there is any purpose to this evaluation of past failures other than to again highlight the several ways in which failures can occur and to raise fears that such failures are inevitable at the Pebble site. While the ICOLD (2001) report is a significant resource when evaluating modes of tailings dam failures and how to prevent them, it is not appropriate to use the database in direct comparison with a modern mining operation that will undergo the rigorous design and permitting process anticipated for the Pebble Project. (Doc. #4611.8, p. 13)
- A comparison can be made to the case histories in the ICOLD report as a basis for evaluating whether appropriate measures are being put in place to mitigate against the failure modes described. With this framework in mind, Table 1 presents an alternate evaluation of the case histories in the ICOLD (2001) report. (Doc. #4611.8, p. 15)

Description	Number of Case Histories	Pebble Mitigation Measure
Total Studied Tailings Dams	220	N/A
After Removing Accidents	136	N/A
After Removing Upstream Construction Cases	31	Downstream / centerline construction
After Removing Foundation Failures	22	Comprehensive investigation Foundation preparation
After Removing Overtopping Failures	15	Sufficient freeboard
After Removing Improper Construction Failures	10	Good construction practices and Quality Assurance
After Removing Improper Operations Failures	8	Modern operations practices and tailings management
After Removing Mine Subsidence Failures	7	Distance
Remaining Cases	0	Various

- The probability of failure discussed in the BBWA, where the ICOLD data is used as a basis for claiming the probability of failure, would be one tailings dam failure for every 2,000 mine years. This probability is not relevant to a modern mining project. An analysis that simply utilizes a retrospective failure rate to estimate future failures at a modern mining site significantly exaggerates the risks of a TSF failure, and therefore results in a biased assessment of future outcomes. (Doc. #4611.8, p. 16)
- By providing specific analytical model results to describe the tailings flow distance and associated sediment deposition from a hypothetical tailings release, the BBWA dam breach analysis appears credible whereas in fact, the analysis is flawed. Given the significant uncertainty and thus low reliability of the numerical estimates, the findings are equivalent to a statement that scenario releases of 55 million m3 or 317 million m3 of fluidized tailings will travel a long way downstream with significant impacts. One need only review local topography to reach that conclusion. The dam breach analysis in the BBWA reinforces the bias of the document rather than informing a scientifically defensible formal risk analysis. (Doc. #4611.8, p. 17)
- The Manning's friction coefficient was increased to *"better reflect the influence of sediment-rich water during tailings dam failure"* (pg. 4-53). The approach using a modified Manning's friction factor (n) is recommended by the HEC-RAS manual (USACE, 2010). However the BBWA does not supply the reader with information as to how they evaluated the appropriate Manning's coefficient, nor do they state the value used. The HEC-RAS Manual provides guidance that the Manning's values are not exact and a range of possible values should be selected, and then multiple model runs should be performed with different values to evaluate the impact in overall flow response. The implications of changes in model parameters would likely be significant given the scale and likely sensitivity of the analysis. Without following the guidance of the HEC-RAS manual or standard engineering practice to evaluate model sensitivity, the results of the analysis cannot be considered reliable. (Doc. #4611.8, p. 17-18)
- 2. The analysis relies on a very coarse 30 meter digital elevation model (DEM) to develop channel bathymetry (pg. 4-53) The coarse nature of the 30 meter DEMs does not account for

channel complexity in the floodplain where side channels or wider braided channels are only activated during floods and are available for sediment deposition. Off channel wetlands and watercourses are also missed. The lack of channel complexity and channel morphology oversimplifies the channel roughness and leads to river channels characterized as too "clean" and "smooth." As a result the coarse model very likely over predicts flows, velocities and sediment transport relative to what would be expected in reality (Crosby, 2006). For the purpose of hydrologic modeling a 30 meter DEM is very coarse and lacks the detail to allow for an adequate calibration of the HEC-RAS model. The HEC-RAS Manual also states that if you are using bathymetric cross sections developed from a 10 meter DEM or coarser "then you should not expect to be able to get good model calibration with such poor terrain data." (USACE, 2010) Poor quality channel bathymetry data can be the source of large instabilities of model performance when performing unsteady flow analysis with HEC-RAS. These instabilities are often attributed to the modeler using land terrain topography data in place of proper bathymetric data. Additionally, wide flat channel beds (similar to the water surface associated with a DEM) cause instabilities because at lower flows the area/depth ratio is high, and when a small increase in flow occurs it is seen as a large relative increase in depth (USACE, 2010). (Doc. #4611.8, p. 18)

- The lateral extent of the cross-sections in the HEC-RAS model were likely insufficient, resulting in increased flow depth and higher velocities (Table 4-13, pg. 4-59) The significant deposition depths computed in the HEC-RAS model are inconsistent with the wider floodplain topography of the last approximately 10 km of the analysis. Stations at 9.4 km, 5.4 km, and 0.6 km from the end of the 30 km analysis show maximum depths of 8.8 m, 8.1 m, and 14.0 m. A review of the topography in the vicinity of these stations indicates the flow would have spread out significantly across a very wide area and would never achieve these depths. It is likely that the lateral extents of the model were insufficient, resulting in HECRAS assigning vertical "walls" at the ends of the cross-section. These walls would result in creating an artificial channel to contain the flow, which in turn would result in unreasonable depths of flow, as well as increased velocity. Both of these artificial impacts (increased depth and velocity) would result in an increased runout distance for the modeled flood. (Doc. #4611.8, p. 18 to19)
- The mine tailings dam breach run-out scenarios are modeled to a distance of only 30 km and the analysis then utilizes a tailings run-out regression equation to calculate total mine tailings travel distances beyond the last segment of the model (pg. 4-57)
  The extent of the sediment transport model should be extended to the river reach where the mine tailings are expected to be transported downstream (e.g. beyond the 30 km marker at the confluence of the North and South Koktuli Rivers). Switching from a simplistic sediment transport approach to an even more simplistic regression equation once the mine tailings reach the confluence of the North Fork Koktuli and South Fork Koktuli Rivers only adds to the uncertainty in the estimates of the distance of sediment transport (Rico et al., 2008). Rico et al. (2008) presents three predictive tailings run-out regression equations based on dam height, waste out flow and a combination of both parameters, with R_2 values of 0.16, 0.56 and 0.57, respectively. The BBWA does not state which of the three regression equations were used in their evaluation of the tailing run-out estimates, but regardless, given the low R_2 values there is limited statistical reliability in any of these equations. Furthermore, of the 28 case studies used to develop the Rico et al. (2008) regression equations, the largest tailings release volume was 9 million m_3 in volume, which is 16% and 3% of the volume of the

partial and full dam release scenario volumes (55 million m^3 and 317 million m^3), respectively. Thus, the regression equations developed by Rico et al. (2008) are insufficient in predicting tailings run-out for the two very large dam break scenarios presented in the BBWA. Additionally, Rico et al. (2008) state that: “the accuracy of these estimations should be approached with great caution.” Rico et al. (2008) also describe the nature and magnitude of the errors associated with their regression equations as such:

> “These errors result from a large variety of parameters affecting the mine waste flow, including sediment load, fluid behavior (Newtonian or Binghamplastic) which depends on the type of failure (e.g. seismic action, static liquefaction, slide, etc.), particle-dependent rheology of the suspension, topography and valley gradient and presence of obstacles impeding the slurry to flow among others. Another source of uncertainty is related to the lack of data related with the water volume existing at the time of failure either stored at the decant pond or linked to the meteorological causes triggering the dam failure (intense rainfall, hurricanes, rapid snowmelt, ice accumulation in the tailings dam, etc.), which may change indeed the hydrologic conditions (peak discharge, tailings outflow volume) and the run-out distance of the tailings.”

The BBBWA does not indicate that the HEC-RAS model was calibrated to demonstrate the model has the ability to predict accurately the river hydraulics in normal stream flow or flood flow conditions. Additional, and more robust, modeling should have been conducted to explore the impacts of the tailings dam breech scenario. (Doc. #4611.8, p. 19-20)

- 5. Sedimentation of the dam break flood wave was calculated when the flood wave was at its maximum predicted depth (pg. 4-57)
  It is not clear when the BBWA states: *“we assumed that sediment deposition could occur in the channel and the floodplain of each section at the maximum predicted channel depth during the peak of the flood wave,”* whether they are assuming sediment deposition occurred only at the maximum stage of the flood wave or whether they are assuming sedimentation occurred at these depths in addition to normal sedimentation processes modeled by HEC-RAS. When river flows are at their maximum flood stage, river velocities are often at their highest, which is not conducive to sediment deposition. The majority of sediment deposition occurs on the receding limb of the flood curve, when river velocities are starting to decrease. (Doc. #4611.8, p. 20)
- 6. The Hjulstrom curve was used to evaluate sediment transport velocity (pg. 4-57)
  The critical deposition velocities shown on the Hjulstrom curve represent the average channel velocity measured one meter above the channel bed. Furthermore, the Hjulstrom curve was developed while observing the transport of only uniformly sized sediment loads, thus ignoring the effects that a distributed sediment load would have on critical transport velocities. While the Hjulstrom curve is a widely used reference to evaluate sediment transport in streams, it is not well-equipped to be used to evaluate sediment settling in a dense, mostly solid flow such as the scenarios set forth in the BBWA.
  When Hjulstrom developed the curve, he used limited deposition velocity data published originally by Friedrich Schaffernak (Self et al., 1988). According to Self et al. (1988) Schaffernak only examined particles 5 mm in diameter and larger. The proposed tailings from the EPA analysis are assumed to have a diameter range of less than 0.01 mm to just over 1.0 mm, so the Hjulstrom curve would provide a lessreliable prediction of settling velocities for the mine tailings. Self et al. (1988) reexamined the reliability of the Hjulstrom curve. Instead of correlating channel velocity with sediment transport they measured the

critical erosion and critical deposition shear stress for particles ranging from 0.014 – 0.141 mm in diameter.
Self et al. (1988) found the critical deposition shear stress to be 3 orders of magnitude larger for the particles examined than values reported by Hjulstrom. The use of the Hjulstrom curve to evaluate critical deposition velocities underestimates the sedimentation of particles at higher velocities, and thus over estimates the amount of sediment transported by the dam breach scenarios. (Doc. #4611.8, p. 20-21)

- 7. The TSF 1 drainage area is incorrect and the maximum flood comparison with USGS record and PMF analysis is flawed (pg. 4-50)
The contributing watershed area to TSF 1 is incorrect and this influences the comparative statistics. Page 4-21 of the report states "*The surface area covered by the TSF 1 at full volume is estimated to be 14.9 km^2 (Table 4-3, Figure 4-7).*" This is in conflict with the report stating on Page 4-50 that the contributing watershed area is only 1.4 km^2. Based on our review of Figures 4-7 and 4-14 the watershed area contributing to the TSF 1 is roughly 17 km^2. In addition, the BBWA states "*For comparison, a U.S. Geological Survey (USGS) gage located near the village of Ekwok, Alaska, experienced a record peak flood of 3,313 m^3/s in a 2,551-km^2 watershed.*" (pg. 4-50) It is unclear which USGS gage was used but the mean daily flow data from the USGS gage on the Nushagak River at Ekwok, AK (15302500) was acquired from October 1st, 1977 to September 30th, 1993. The maximum daily flow during this period was 3,228 m^3/s and the drainage area associated with this gage is 9,850 mi^2 (3,449 km^2). Using this information on a unit area basis (110 $m^3/s/km^2$ for partial release and 701 $m^3/s/km^2$ for full release) the partial-volume failure analysis would result in 117- fold increase (not 1,000-fold) in discharge compared to the flow observed at the USGS gage and for the full volume failure analysis, there would be a 750-fold increase (not 6,500-fold). The BBWA overstated the increase in flow by almost one order of magnitude (i.e. almost 10 times).
In addition the report inappropriately compares the peak flow from a dam failure (partial: 1,862 m^3/s, full 11,915 m^3/s) from a probable maximum flood (PMF) analysis (using the probable maximum precipitation, PMP) with the maximum stream flow at a USGS gage at Ekwok (15302500) from a 16 year record. A PMF is an estimate of the largest flood theoretically possible from a combination of severe hydrologic and meteorological conditions that are reasonably possible for the drainage basin in question. During a PMF event, the stream flow below the TSF dam would already be significantly higher on a unit area basis than a peak measured downstream from a 16 year record. As such, even the corrected 117-fold and 750-fold increases discussed above are overstated, because the baseline flow in the creek would be higher during the PMF. (Doc. #4611.8, p. 21)
- The first inadequacy in the BBWA analysis is the lack of a clear definition of what constitutes a "failure" of the water collection and treatment system. The examples and language used throughout the document suggest that the temporary loss of a system component is considered a "failure" and the report presents such a failure as a virtual certainty. The report overlooks the fact that failure of a minor system or component (e.g. a mechanical pump breakdown or an electrical instrumentation failure) can be quickly and relatively routinely addressed, and is thus unlikely to cause a release of hazardous substances or result in any material environmental impact. Also, no distinction is made between a minor release that causes no environmental impacts outside of the site boundaries and a major release that could result in potentially environmentally significant impacts beyond the site.

(Doc. #4611.8, p. 22)

- In Box 4-1 (pg. 4-24) the BBWA aggregates multiple worst-case failure scenarios into a single release event scenario which unreasonably overstates the probability of release due to a system failure in the water collection and treatment system. The cumulative effect of four worst-case factors (unlimited oxygen supply, higher concentration of metals in the waste rock, high leaching rates due to small grain size, and high water contact due to the absence of preferential flowpaths) sets an overly conservative bound on the hazardous characteristics of the leachate quality. Use of the additive result of multiple concurrent worst-case factors, represents an unreasonable overstatement of the potential impacts of leachate releases. A risk analysis based on these assumptions cannot be well supported scientifically. (Doc. #4611.8, p. 22 to 23)
- The inferences drawn in the report also do not account for advances in technology or operational practices between the historical case studies examined and present practices. The assessment acknowledges that some case studies cited incorporated historical and outdated mining practices that would not be allowed under current mining laws. Several passages of text use language that are not technically correct and, as a result, can be confusing or misleading. Some examples follow: (Doc. #4611.8, p. 23 to 25)
  - "…variety of geochemical models ad approaches to understand and predict releases to the environment…" (pg. 4-4)
    The use of geochemical models cannot predict releases to the environment. Geochemical models are useful for predicting chemical reactions that may occur under different environmental conditions; however, the chemical reactions and processes referred to in Section 4.1.2 are only likely to occur if conventional interventions are not utilized. (Doc. #4611.8, p. 23)
  - "…there are limitations in our ability to make predictions with a high level of certainty because of the inherent complexity of natural materials and their environment." (pg. 4-4)
    Although some of the risk factors described such as site geology and climate are naturally occurring and inherently variable, the activities of mining, ore processing, and residuals management methods are within the purview of the mine operations. Water management, including collection and treatment, is expected to be an active part of the mine operations, and adjustments to optimize the processes will be expected throughout the life of the mine, during reclamation, and post-closure. These on-going adjustments to the water management systems and processes are a normal part of managing the "inherent complexity of natural materials." (Doc. #4611.8, p. 23)
  - "One way to predict if acid generation will occur is to perform acid-base accounting tests." (pg. 4-4)
    The acid generation tests do not predict if acid generation will occur, only the potential for it to occur. From the Wardrop (2011) preliminary assessment, it is apparent that active management of the two main mine residual streams, potentially acid generating (PAG) and non-acid generating (NAG) tailings, will be implemented to reduce the potential exposure of the PAG to oxidizing conditions. Approximately 15% to 20% of the tailings are expected to be PAG, with the remaining 80% to 85% being NAG. The submerged discharge of the DRAFT Technical Review of May 2012 Draft Report EPA 910-R-12-004a Final BB Assessment Review - 07-18-12 - R1.docx

19 July 2012 PAG tailings within the tailings storage facility (TSF) is standard practice to reduce the potential for the acid generating chemical reactions to occur. This is another example of implying an outcome (in this case acid mine drainage problems) without accounting for obvious and widely used mitigation measures at modern operating mines. (Doc. #4611.8, p. 23 to 24)

  - "Additionally, some toxic elements (e.g., selenium and arsenic) may be released from mining materials under neutral or higher pH conditions…" (pg. 4-5)
    This statement is technically inaccurate and misleading, as a toxic release is not assured in the instance described. Uncontrolled releases to the environment are unlikely to occur in a modern mining operation, as active measures and precautions are taken to prevent this outcome. Similarly, should a release occur, remedial actions can be taken to prevent or minimize the extent of the impacts, with a goal of retaining any releases on site property for proper capture, treatment and management. (Doc. #4611.8, p. 24)
  - "Because premature closure is an unanticipated event, water treatment systems would likely be insufficient to treat the excessive and persistent volume of low pH water containing high metal concentrations." (pg. 4-33)
    Past experiences with premature closure at mining sites has resulted in requirements for financial assurance as part of the modern permitting process for mine operations. Given the known financial and regulatory safeguards anticipated to be in place, including means for operation of water collection and treatment systems during post-closure, there appears to be no basis or justification for this statement regarding the likelihood that the water treatment systems would be overwhelmed by an "excessive and persistent" volume of water to manage. (Doc. #4611.8, p.24)
  - "The volume of water that would require treatment by the mine wastewater treatment plant is unknown at this point, but could be very high. To avoid or minimize risks associated with altered streamflows in downstream effluent receiving areas (Section 5.2.2.1), capacity for water storage and release would be required in order to maintain natural flow regimes or any minimum flows required by ADFG. Maintenance of mine discharges in terms of water quality, quantity, and timing, to avoid adverse impacts would require long-term commitments for monitoring and facility maintenance. As with other long-term maintenance and monitoring programs, the financial and technological requirements could be very large, and the cumulative risks (and likely instantaneous consequences) of facility accidents, failures, and human error would increase with time. We know of no precedent for the long-term management of water quality and quantity on this scale at an inactive mine." (pg. 5-45)
    In this statement, the BBWA illustrates a lack of understanding of post-closure operations at formerly active mining sites. A standard component of modern mines is to provide significant financial assurances for long-term maintenance and monitoring programs. This is a standard component of the permitting process to ensure the long-term program is adequately funded. (Doc. #4611.8, p. 24 to 25)
- Figure 4-9B incorrectly depicts a post-closure scenario with no water management. As described in the Wardrop (2011) report, the closure planning process includes long-term water management and financial sureties to ensure that the closure plan will remain funded. (Doc. #4611.8, p. 27)
- As part of the management and operation of environmental control systems, planning for

unforeseen events by having mitigation plans in place is a typical practice. Critical services would also include containment or other countermeasures to be protective of the environment.

- "Failure to properly collect and treat leachate from waste rock piles, TSFs, or other areas of the mine site may allow potentially toxic chemicals, soils, and particulate matter to enter streams. Here, we consider the failure of on-site collection and storage practices at TSF 1 as an example case. Based on the available data, estimation of potential flow through the substrate located under and around proposed TSFs requires several assumptions." (pg. 4-39)
- "With a dam height of 98 m, estimated flow rate at the downstream face of the tailings dam would be 8.14x10-4 m3/s; with a dam height of 208 m, estimated flow rate was 1.15x10-3 m3/s." (pg. 4-39) The BBWA considers the failure of the entire on-site water collection and storage system to be a realistic scenario. In reality, such an outcome would be an unlikely event. The water collection system consists of a well field, not a single monitoring/recovery well.

The use of multiple wells with overlapping zones of hydraulic influence provides redundancy to reduce the probability of failure to capture leachate. The presence of a well field also minimizes the impact from a mechanical or electrical failure at any one well. Notwithstanding, if the stated estimates of seepage flow under TSF 1 are correct, in the event of a water collection system failure, the range of flows (approximately 13 to 18 gallons per minute) is comparable to that of one or two household garden hoses. In the unlikely event of a complete collection system failure, any seep water can be managed using interim collection and treatment measures. For example, seep water flowing to the surface could be captured in a surface swale and pumped to the top of the TSF by the use of portable gas-powered pumps. The consequences of the failure proposed in the assessment could be effectively mitigated quickly and easily. (Doc. #4611.8, p. 32)

- The reported nearly 10-fold difference between the annual water discharge volumes under minimum and maximum mine operations represents an additional opportunity for robust design and continuous improvement to guard against potential failures of the water collection and treatment systems. The treatment system may be constructed in stages utilizing parallel treatment trains as appropriate, which would have the added benefit of providing redundancy and backup during maintenance and repairs. (Doc. #4611.8, p. 32)
- Assessment of Applicability of References on Pipe Failure Rates
  The BBWA uses three sources of pipeline failure statistics to calculate an annual failure rate of 0.0010 per kilometer (e.g. failures per km-yr) of pipeline using the geometric mean of three selected values. Based on this overall estimate of the failure rate and the proposed length of the transportation corridor (139 km), a probability of 14% (i.e. 0.0010 failures per km-yr x 139 km) was calculated for the failure rate in each of the four pipelines per year. Among several data sources presented in Table 4-14 of the report, the following three data sets were used in the assessment of annual pipeline failure rate:
  a) OGP 2010 (oil pipelines) – a failure rate of 0.0010 for onshore oil pipelines with diameter < 20 cm;
  b) URS 2000 (56 US oil pipeline operators) – a failure rate of 0.00062 for the 10 smallest operators (< 418 km of pipeline); and
  c) Alberta Metal 2011 – a failure rate of 0.0016 reported in Alberta, Canada in 2009.
  The validity of the overall failure rate estimate of 14% is questionable due to the following

reasons:

1. These data sets are not representative of all the conditions in the Bristol Bay watershed. The first and second data sets are based on various oil pipelines throughout the US, while the third is based on a gas pipeline in Canada. None are based on mining industry findings. The direct comparability of oil and gas (O&G) industry failure data to mining industry data, given the differences in regulatory and permitting frameworks, is questionable. Furthermore, O&G distribution pipelines are often under shared ownership for common sections, or alternate ownership for interconnecting sections. The degree of stewardship (inspections, maintenance, etc.) and resulting observed failure rates in these two scenarios may reasonably be expected to differ.
2. The geometric mean has been applied to the data without justification. These data sets are dissimilar to each other (i.e., physical, environmental, temporal, and maintenance differences), thereby making it statistically invalid to average over all three. In particular, if an estimate is to be calculated from multiple sources, rather than averaging, the failure rate should be estimated accurately from data pooled across the sources. Averaging across multiple failure rate estimates obtained from different populations can produce misleading estimates, especially if the populations do not have the same underlying structure. In order to pool the data sets to obtain a high quality estimate, each data set must share the same underlying mechanism driving the failure rates. In this case, the failure rates clearly come from three (or more) different populations, and the underlying source data is not readily available for analysis. Hence, the overall estimate of the failure rate is not only skewed by averaging over these multiple sources, but it is also subject to uncertainty as the source data sets may not be compatible.
3. There is little information regarding the methods used to calculate the individual failure rates from each of the aforementioned sources. More specifically, it is unclear whether these failure rates are a sum of all failure types (external corrosion, internal corrosion, mechanical defect, etc.) and failure classes (near miss, small leak, large leak, rupture). Accounting for these factors differently would explain some of the spread in the failure data and potentially limit its applicability, more so in light of the averaging of potentially incompatible data sets described above.
4. The validity of the source data itself is questionable. None of the sources in Table 4-14 are properly cited. We have been unable to conclusively identify the "URS 2000" source as of this writing. The "Alberta Metal 2011" reference is a single anecdotal statement in a trade news publication. 5. The possibility of underground pipe routing does not appear to be addressed. The Wardrop (2011) report, which is referenced as the source of the mine scenario in the BBWA, explicitly states on page 331 that the majority of the piping will be buried adjacent to the proposed roadway. Buried piping is at greatly reduced risk of physical impact damage, which is repeatedly cited as one of the chief failure modes of the pipelines. We recognize that there are other challenges associated with buried pipelines (ease of inspection and repair, etc.) but an appropriate relative risk assessment has not been included in the BBWA which would certainly influence the stated failure rates. (Doc. #4611.8, p.35-37)

- **Assessment of the Statistical Validity of Failure Rate Calculations for Pipelines**. While not stated in the report, our analysis indicates that the BBWA has assumed the pipeline failure rate will follow an exponential distribution. We reach this opinion because with an annual probability of failure of 14% and a 25 year mine scenario, an exponential cumulative distribution function predicts the probability of a pipeline failure occurring in at least one of the four pipes to be approximately 98%, consistent with the value used in the BBWA. This estimated 98% failure rate is considered misleading for the following reasons:

1. The use of the exponential distribution assumes a constant failure rate which is not realistic in this case. If, as stated in the report, the two major failure modes are physical impact and corrosion, then the first may be expected to vary as a function of time due to construction activity, production increases, seasonal effects etc. The second may be expected to vary directly with time since corrosion is a time dependent phenomenon. Thus, for example, the actual failure rate during the initial period of steady state operation may be far lower than the estimates suggest since corrosion rates will be vanishingly small and vehicle impact risk will be at a local equilibrium. The assumption of a constant failure rate is too simplified for the assessment of the reliability of a complex pipeline system. Failure rates are known to be affected by multiple factors such as third party damage, corrosion, design, incorrect operations, etc. In order to calculate a reasonably accurate probability of pipeline failure, these additional factors must be considered. Consequently, the failure rate trend may change from factor to factor, and furthermore, some may have a decreasing effect if controlled.
2. The probability of a pipeline failure in 25 years is assumed to be the same for each of the four pipelines. However, in Section 6.2 the BBWA states: "We do not assess failures of the natural gas or diesel pipelines here because such pipelines are common, their risks are well known, and they are not particularly associated with mining." Furthermore, the service conditions, line sizes, and potential failure modes of each of the four lines are very different, which makes the assumption of a single, common failure rate highly questionable. We note that while the BBWA states that "they are not particularly associated with mining," they use failure statistics from the oil and gas industry to develop their statistics for mining pipelines.
3. The probability of failure is calculated based on a failure rate of 14%, applied uniformly along the entire pipe. This implies that each segment of the pipe is equally susceptible to failure. However, certain areas of the pipeline will be more susceptible to failure than others, e.g. in heavy traffic areas, under certain soil conditions etc. Furthermore, the consequence of a failure is highly dependent on its location. Outcomes will be far different for a failure which occurs inside engineered containment (e.g. a valve vault), vs. at a stream crossing. Proper risk analysis must account for both the likelihood of failure and the consequences of that failure. Finally, areas of high risk would be identified and extra controls put in place during the design phase, to reduce the failure risk at those points to acceptably low levels. (Doc. #4611.8, p. 37-38)

- Assessment of Pipeline Release Scenario
  Section 4.4.3.2 of the BBWA presents the scenario of a pipeline failure. Evaluations are performed for the four pipelines, though the primary failure scenario in the assessment is for the concentrate pipeline, with basic components as follows:
    - Full pipeline break;
    - Pumping rate = 254.8 metric tons/hour;

- Pipe diameter = 20.3 cm;
    - Remotely activated shutoff valves, with 2 minute lag from failure to shutdown; and
    - Distance to nearest shutoff valve = 14 km.

  The volume of release due to a pipeline failure, as described in the report, is heavily dependent on the length of pipeline between two isolation points which define the maximum trapped volume which could be released. In Table 4-15 in the BBWA, for the concentrate pipeline, the volume of flow over 2 minutes is 5.1 m3, while the volume between isolation valves is 470 m3. The BBWA characterizes this minimum distance as 14 km based on the need to have isolation on either side of every major river crossing and cites the Wardrop (2011) report as support. However, the Wardrop (2011) report (pg. 332) characterizes major river crossings as 600 ft (0.18 km) wide for design purposes. The 14 km assumption thus produces unrealistically high (14 km vs. 0.18 km) representative release volumes in Table 4-15. Proper design would include more frequent and strategically placed points of isolation, which would work in concert with automatic leak detection to minimize potential leakage along critical stretches of the pipeline. (Doc. #4611.8, p.38)
- Risk Characterization Based on the Mine Scenario
  The first statement in Section 6.2.1.3 is "A pipeline failure and spill would be expected to release 366,000 L of leachate (Table 4-16)." (pg. 6-34) This assertion is problematic as a baseline for risk characterization because, as discussed in Section 4.3, the release volumes are potentially overestimated based on isolation valve considerations. (Doc. #4611.8, p.39)
- Based on a review of the Wardrop (2011) report, most, if not all, of the measures described in Appendix I are proposed for the transportation corridor pipelines at Pebble. Although the Wardrop report does not represent the final project plan, it is anticipated that the project would take significant steps to implement modern practices to mitigate against the potential pipeline failures described in the BBWA. While mitigation measures are referenced in Appendix I, by not incorporating the application of mitigation practices that would significantly reduce the likelihood of pipeline failures into the risk analysis, the BBWA provides a flawed and inaccurate assessment of the pipeline failure concern. (Doc. #4611.8, p. 41)
- **Seismic Environment**
  In Section 4.4 of the BBWA, significant attention is given to the seismic environment within the project vicinity and potential seismic impacts. The majority of the discussion is presented in three boxes within the report as follows:
    - Box 4-3: The Seismic Environment of Bristol Bay (pg. 4-38)
    - Box 4-5: Earthquake Effects (pg. 4-43)
    - Box 4-6: Selecting Earthquake Characteristics for Design Criteria (pg. 4-48)

  Seismic criteria are a critical component of design of major infrastructure projects. However, many of the concerns raised in the BBWA are overstated and inconsistent with a modern understanding of seismic risks to engineered structures such as the TSF.
  Box 4-3 describes the general seismic environment of Southwestern Alaska with a focus on the vicinity of the Pebble Project. The most significant potential seismic hazard to the project is likely to be the potentially active Lake Clark Fault. Box 4-3 states:
  > "The western terminus of the Lake Clark Fault was originally interpreted to be near the western edge of Lake Clark, but more recent studies by USGS reinterpreted the position of the Lake Clark Fault further to the northwest, potentially bringing it as close as 16 km

to the Pebble deposit (Haeussler and Saltus 2004). Haeussler and Saltus (2004) acknowledge that the fault could extend closer than 16 km, but data are not available to support this interpretation. USGS has concluded that there is no evidence for fault activity or seismic hazard associated with the Lake Clark Fault in the past 1.8 million years, and no evidence of movement along the fault northeast of the Pebble deposit since the last glaciations 11,000 to 12,000 years ago (Haeussler and Waythomas 2011). Recently, the Alaska Division of Geological and Geophysical Surveys and USGS investigated reports of a surface geological feature (the Braid Scarp) near the Pebble deposit that was reported to be a fault scarp, indicating recent movement of a fault (Koehler and Reger 2011, Haeussler and Waythomas 2011). Both agencies independently determined that the feature was a relic of glacial activity and did not represent evidence of recent faulting." (Box 4-3, pg. 4-38)

Following these statements of findings from the literature on the Lake Clark Fault which present a case of low seismic risk, the BBWA goes on to make statements such as the following:

> "Although there is no current evidence that the Lake Clark Fault extends closer than 16 km from the Pebble deposit, and there is no evidence of a continuous link between the Lake Clark Fault and the northeast trending faults at the mine site, mapping the extent of subsurface faults over long, remote distances is difficult and has a high level of uncertainty." (Box 4-3, pg. 4-38)

> "Large earthquakes have return periods of hundreds to thousands of years, so there may be no recorded or anecdotal evidence of the largest earthquakes on which to base future predictions. While geologic analyses and field studies of existing faults can provide evidence of surface rupture and bounding estimates of the age of movement, these data are not unique and are subject to many uncertainties." (Box 4-3, pg. 4-38)

Statements like these do not serve to quantify risks, but rather to raise alarm and bias the assessment. The report is in essence stating that rather than use appropriate design techniques based on the best available knowledge of actual risks, the design should instead be based on hypothetical scenarios that are not supported by actual data. The BBWA is applying a zero-risk framework to the risk analysis of the mine development. This is inconsistent with engineering best practices.

Glacially formed terrain is very useful for evaluating the evidence of faulting, because the glaciers left a clean slate prior to receding over 10,000 years ago. Active faulting within the area north of Lake Iliamna should leave a trace that is visible, such as offsets in stream channels, erosional features, or other surficial geologic evidence that geologists are trained to detect. Geophysical methods (e.g. Haeussler and Saltus, 2004) are available to seek evidence that is not visible at the surface.

This zero-risk framework is evidenced in the Box 4-6 language as well. The box begins with background on the Alaska Dam Safety Regulations (ADNR, 2005), which establishes the operating basis earthquake (OBE) and maximum design earthquake (MDE), where the latter is the larger event and will control the tailings dam design. After the opening discussion, the report goes on to make the following statement:

> "The mine scenario in this assessment includes approximately 25 to 78 years of mineral extraction, with likelihood that additional long-term operations would be required for closeout and maintenance of the mine. This time period is barely within the OBE return period for Class II dams. The MDE analysis presents a potentially greater risk of

underestimating the size of a characteristic earthquake. Tailings storage facilities (TSFs) will operate during the active mining period and could have a life expectancy of 10,000 years after operations cease. Because the return period for the MDE is 1,000 to 2,500 years, this could lead to significantly underestimating the largest earthquake that is likely to occur." (Box 4-6, pg. 4- 48)

Note that the Wardrop (2011) report indicates that the TSF design will be based on the Maximum Credible Earthquake (MCE). The MCE, as defined by ADNR (2005) is "the greatest earthquake that reasonably could be generated by a specific seismic source, based on seismological and geologic evidence and interpretations." As such, every potential fault that could impact a project has its own MCE, and the design must consider the most critical fault(s) for the project.

Wardrop (2011) indicates that the preliminary hazard classification of the dam is Class II, consistent with ADNR (2005) guidelines. However, use of the MCE confirms that the project engineers view the TSFs as Class I hazard level facilities. In our opinion, this is an appropriate standard for these critical structures. As a Class I facility, the OBE earthquake would have a return period of 150 to >250 years, which is well beyond the operational life of the mine, and the MDE ranges from the 2,500 year event to the MCE.

Box 4-6 of the BBWA finally goes on to discuss their understanding of the seismic design criteria proposed by Northern Dynasty Minerals (NDM) for the Pebble Project. It is not clear why a detailed discussion of the outdated approach described in the 2006 preliminary assessment (NDM, 2006) is presented, and only afterwards is it noted that a more conservative seismic basis is presented in the Wardrop (2011) report. The discussion of the NDM (2006) data is confusing and unnecessary considering that the BBWA states that the Wardrop (2011) report is the basis for their mine scenario.

While the seismic discussion in the three boxes is extensive, the references within the main text of the report are limited and very general. The most significant references to earthquakes in the main text of Section 4.4 include the following:

> "The potential for accidents and failures resulting from earthquakes may be of particular concern in our mine scenario, given that southwestern Alaska is a seismically active region (Box 4-3)." (pg. 4-37)
>
> "Earthquake. Shaking resulting from earthquakes (Table 4-7, Figure 4-11, Box 4-5) causes additional shear forces on the dam that can lead to a slope instability failure." (pg. 4-40)
>
> "This [detailed computer stability] analysis considers the effects of earthquakes based on a site-specific evaluation of seismicity in the area. Box 4-6 describes the selection of earthquake characteristics for design criteria." (pg. 4-46)

It appears that while the text in the boxes is intended to alarm the reader, the authors of the BBWA are not certain how to incorporate the actual seismic risk into their analyses, and hence as shown in the statements above, they choose not to.

The discussion under "Recommendations for Future Work" at the end of Haeussler and Waythomas (2011) provides a good summary of the USGS position on the current status of seismic knowledge in the vicinity of the Pebble Project.

> "A broader evaluation of potential seismic hazards in this region would be useful prior to preparation for future developments. ... most of the deposits near the Braid Scarp are likely 11,000 to 16,000 years old. If there have been surface faulting events within this time period, traces of active faults should be easily observed. Thus far, no active fault

traces have been identified in the region, although it is possible that some active fault traces are obscured beneath vegetation, talus, alluvial deposits, and other mass-wasting deposits..." "The only fault that has been identified as having possible Neogene (that is, in the last 23 million years) activity in the region is the Lake Clark fault. Haeussler and Saltus (200[4]) found that the Lake Clark fault has had about 26 km of offset in the last 34–39 million years, but that conclusion does not mean the fault is active today. In their compilation of active and Neogene fault traces in Alaska, Plafker and others (1994) categorized the Lake Clark fault as a fault trace of pre- Pleistocene age. In other words, they found no evidence that there had been offset along the Lake Clark fault within the past 1.8 million years. Several studies that focused on the Lake Clark fault in the region northeast of Lake Clark found no evidence for movement along the fault since the last glaciation, around 11,000– 12,000 years ago (Plafker and others, 1975; Detterman and others, 1976; Reger and Koehler, 2009). Thus, there is no evidence for active faulting or seismic hazard associated with the Lake Clark fault. In summary, if further geologic studies find no evidence for surface faulting, it would be difficult to conclude that a significant seismic hazard exists from crustal faults in the area."

None of this is meant to downplay the hazards associated with earthquakes in Southwestern Alaska and at the Pebble Project. Seismic shaking, deformation, liquefaction, landslides, seiche and other seismic hazards are real and must be accounted for during design. However, based on our review of the Wardrop (2011) report and the Environmental Baseline Document (PLP, 2011), indications are that the project engineers are aware of those hazards, and current design standards provide means to mitigate the impact of seismic events with an acceptable degree of certainty.

Wardrop (2011) indicates that geological and geophysical studies have been performed to further evaluate the possible extension of the Lake Clark fault. Although indications of those studies continue to show a limited likelihood of activity for the Lake Clark Fault, the project is likely to be based on evaluation of both a distant MCE magnitude 9.2 earthquake offshore, and a nearby Lake Clark scenario fault with an MCE magnitude of 7.5. With maximum credible ground accelerations computed by Wardrop (2011) for the Lake Clark scenario in the 0.44g to 0.47g range, we consider that a suitably conservative seismic earthquake scenario has been established.

In summary, the seismic analysis provided in the BBWA:

1. is biased by unsupported hypothetical faults rather than relying on the substantial geological, geophysical and seismological evidence of the seismic environment in the vicinity of the Pebble Project;
2. does not acknowledge that seismic risks will be evaluated thoroughly by the ADNR and others during the permitting process;
3. does not incorporate the seismic risks (real or hypothetical) in their watershed risk analysis; and
4. does not acknowledge that modern engineering and science can be used to develop a project that will meet seismic reliability criteria in this environment.

(Doc. #4611.8, p. 48-53)

Alaska Miners Association, Inc. (Doc. #4612.2)

- With respect to dam failure, the Assessment indicates that if the reclamation plan used a dry closure rather than a wet closure, it would essentially eliminate the post-closure dam safety risk (p. 4-48). We do not know what Pebble will eventually propose (or what the governments would authorize), but it is odd for the EPA to propose a hypothetical mine with certain risks and ignore design changes that would eliminate the risk. It is incorrect to assume that a risk that could be eliminated is "typical" of large-mine risks for Bristol Bay. Similarly, the Assessment assumes that product from a pipeline break within 100 feet of a stream will enter the stream. The Assessment also routes the pipeline within 100 feet of a stream for a significant portion of its length (i.e., not just at stream crossings). This seems self-evidently wrong. If it were such a problem, why would a mining company or a government-permitting agency not move the pipeline further from the stream? These and other design changes would significantly reduce or eliminate the impacts that the Assessment predicts. These and other examples are explained further in Sections 3 and 4 of this technical review. (p. 21 to 12)

- The Assessment acknowledges this possibility. "After mine closure, TSF can be drained, eliminating the consequences of tailings dam failures (p. 4-48; emphasis added)." Despite this potential to eliminate the risk, the Assessment uses a wet closure to represent what they expect to be typical of large-mine impacts in Bristol Bay. They decline to impose a dry closure, which would eliminate the risk. For reference, Alaska has permitted four open-pit mines in the modern era: Red Dog, Fort Knox, Illinois Creek, and Rock Creek. Only one of the four mines-Red Dog-is proposing a wet closure in its reclamation plan. Therefore, it is quite likely that the Dam Failure scenario is not generally representative of large mine impacts in the Bristol Bay watershed. In addition, it may not be representative of Pebble. Neither the EPA nor the authors know whether Pebble will propose a wet or dry closure. (p. 38)

Alaska Marine Conservation Council (Doc. #4112.2)

- The Assessment does a good job of noting earthquakes as a potential trigger for failure over the short or long-term. However, in box 4-3 describing the seismic environment of Bristol Bay, they overstate the strength of our current scientific knowledge about seismic risk in the area, implying that the lack of evidence for past earthquakes is evidence that no such earthquakes have ever occurred. This section fails to reference the most current and appropriate publication on the largest nearby fault by Koehler and Reger 2011, Reconnaissance Evaluation of the Lake Clark Fault, Tyonek Area, Alaska. This publication makes clear seismic uncertainties: "The paleoseismic history of the [area near Pebble] remains unknown." (p. 4)

Center for Science in Public Participation (Doc. #4106.2)

- It is noted that: “Northern Dynasty Minerals (NDM) also reports that the preliminary design incorporates additional safety factors, including design of storage facility embankments to withstand the effects of the MDE and a magnitude 9.2 event. In 2011, the NDM Preliminary Assessment Report states that an MCE of magnitude 7.5 with 0.44g to 0.48g maximum ground acceleration was used in the stability calculations for the tailings dam design.” (Draft Assessment, p. 4-48, Box 4-6. Selecting Earthquake Characteristics for Design Criteria) In addition to determining the magnitude of the Maximum Design Earthquake/Maximum Credible Earthquake, the other critical factor in determining the maximum ground acceleration is the distance of the event from the mine. The energy from an earthquake 18 miles away (PLP's current assumption) is significantly less than the energy from a "floating earthquake" of the same magnitude at 5 km under the site. (p. 5)

- It is noted that: "Time to pipeline shutdown of 2 minutes" (Draft Assessment, p. 4-62) It is reasonable to assume pipeline shutdown in 2 minutes, if the safety measures work as designed. However, it seems like this is often not the case. Is data available on the average shutdown time for a tailings pipeline spill? (p. 5)

<u>Stratus Consulting (Doc. #4772)</u>

- **Chapter 4. Mining Background and Scenario** "We used outputs from the one-dimensional Hydrologic Engineering Center's River Analysis System (HEC-RAS) hydraulic model (Box 4-8) to estimate tailings deposition along the stream network (Figure 4-14), based on calculated water depths and the assumption that tailings would settle at these depths as the velocity of sediment rich water decreased across the floodplain."
  This analysis is based on using HEC-RAS to model flood routing over a 30-meter resolution digital elevation model (DEM). There are likely to be very high uncertainties associated with using such a low-resolution DEM to model a flood wave in this way (e.g., Casas et al., 2006), which EPA acknowledges on p. 4-56. However, the depth of fine-grained sediment deposition also may not be as crucial as its spatial extent, as habitat degradation can be expected wherever fine-grained sediments are deposited (e.g., Suttle et al., 2004). Given the high uncertainties in modeling the depth of the flood wave and the depth of sediment deposition, this analysis should be removed or replaced with an evaluation of the downstream extent of fine-grained sedimentation in the affected streams. It is ultimately this fine-grained sedimentation that is likely to affect salmon habitat. (p. 3)

<u>Kendall Barbery (Doc. #4110.2 and Levelock Public Hearing)</u>

- I would like to suggest a possible improvement in the EPA Watershed Assessment regarding reservoir and mine induced seismicity. I am appreciative of the efforts of the EPA in giving some credence to the risk of induced seismicity in Chapter 4, yet I would like to see the addition of a few current resources on the subject. There is more recent data available that addresses the relationship between mining and tailings impoundments, and induced or triggered seismic activity (McGarr, Simpson, and Seeber 2002, in addition to the other resources listed below, has beneficial information as well as additional references worth considering). (p. 1)
- Mining, mine-pit dewatering, and tailings storage may increase pore pressure, plate lubrication, tectonic stress and fault slip around a mine site. Even at low magnitudes, induced or triggered earthquakes could lead to increased liquefaction, tailings pond failure, leaching from tailings impoundments, and chronic contamination of Bristol Bay waters. (p. 1)
- Considering the potential combined size of the tailings impoundments and mining operations at the proposed Pebble Mine, the shift in water balance across the landscape could have serious implications for the tectonic stability of the mine and the surrounding region. (p. 1)
- Although the Lake Clark Fault itself is considered inactive (according to the PLP 2011 EBD), and the precise terminus of the fault line is unknown, a 2002 study suggests that triggered earthquakes are just "as likely in stable as in active tectonic settings" (McGarr 2002 p659). No studies address the compounded impacts of a vast mining district on induced seismicity, and vice versa. (p.1)
- Though Bristol Bay communities might not be at direct risk in the event of induced

seismicity, such an event may increase the probability of tailings impoundment failure that could have lasting degrading impacts on the surrounding ecosystem (Chambers and Higman 2011) and the communities who rely upon the vitality of the regions renewable resources for income and subsistence. The risks of triggered or induced seismicity must be considered alongside other seismic data and I encourage the EPA to add to the existing report with a more thorough assessment of the associated risks. (p. 1)

- Mining, mine-pit dewatering, and tailings storage all stand to alter hydrologic regimes, pore pressure, plate lubrication, and tectonic stress around a mine site. Both mining and reservoirs, including open-pit mining and tailings impoundments, are linked to induced seismicity—in which these circumstances speed up or induce the occurrence of an impending earthquake—as well as triggered seismicity—wherein such activity triggers earthquakes in areas otherwise not associated with seismic activity. Cases of reservoir-induced seismicity have had devastating impacts, including the loss of lives and livelihoods and the impairment of ecosystems and waterways (see LaFraniere 2009 and McGarr, Simpson, Seeber 2002). Although the Lake Clark Fault itself is considered inactive (according to the PLP 2011 EBD), a 2002 study suggests that earthquakes can be triggered by minute stress changes and triggered earthquakes are just "as likely in stable as in active tectonic settings" (McGarr 2002 p659). (p. 2)
- I'd like to suggest a possible improvement to the EPA watershed assessment regarding the reservoir and mine induced seismicity. I'm appreciative of the efforts of the EPA and giving some credence to the risk of induced seismicity in the assessment, I believe on page 4-38, yet I'm a little disappointed to find that it warranted only one paragraph and a single citation from a 1976 study. Additional and more current data is available that addresses the link between mining, tailings activity and seismic activity. Mining, mine pit dewatering and eventual refilling of the mine pit, as well as tailings storage, may increase pore pressure beneath the site and lubrication, tectonic stress and fault slip in a mine site. Even at low magnitudes, current triggered earthquake could lead to increased liquefaction, tailings pond failure and chronic contamination of the Bristol Bay watershed. The size of the proposed operations at the Pebble Mine site, along with the potential development of other adjacent mineral deposits could significantly impact the water balance across the landscape and have serious implications for the tectonic stability of the proposed mine and the surrounding region. Although the Lake Clark fault is considered inactive, a 2002 study which I can provide you with citations, suggests that triggered earthquakes are just as likely in stable as in active tectonic settings. Induced seismicity may increase the probability of tailings impoundment failure, and that is something that we cannot risk here in BB. For that reason, I think it warrants further study by the EPA. Risks must be thoroughly addressed to protect BB resources and its vibrant communities. (Levelock Public Hearing, p. 15-16)

<u>Vivian Mendenhall (Doc. #4113.1)</u>

- "The pyrite-rich tailings would be encapsulated in non-acid-generating tailings" (EPA 2012, p.4-19). But it is not clear how these tailings would be sealed permanently from the overlying water. Pond water is likely to reach acid-forming, metal-contaminated tailings through crevices in the "encapsulating" layer; as ion concentrations equalized, contamination of the pond would gradually increase. Oxidation of contaminants in pond water would be assured, due to regular mixing of this water (see next paragraph). (p. 9)
- Tailings would be covered "with a water cap maintained in perpetuity to retard oxidation of

sulfide minerals" (EPA 2012, p.4-19). However, it is not clear how this cap of clean water could be maintained. Sediment-laden water will be added continually to the pond during operations. Even though it "would be discharged below the water surface" (EPA 2012, page 4-21), this inflow will create constant turbulence in the pond. Oxidation of these sediments will proceed rapidly in the well-mixed water; and birds and other wildlife will have access to the pond. No clean "water cap" will remain on the pond after mine closure, under foreseeable conditions. All water bodies are mixed by the wind, which occurs often in Alaska. Furthermore, all water bodies undergo seasonal overturn, which mixes them top-to-bottom as deep as several hundred feet (Smith 1973, Schultz 2012). It can be assumed that these conditions will apply to Pebble's tailings ponds. (p. 9)

- "In a TSF . . . trace amount [sic] of carbonate or silicate minerals will partially neutralize acid" in mine waters (EPA 2012, page 4-23). But the capacity of water in the Pebble area to neutralize sulfuric acid is limited, since it is "soft" water with very low concentrations of buffering salts. (p. 9)
- Water in the mine pit would be acidic and would be contaminated with metals (EPA 2012, page 4-31). This water would leach into the surrounding groundwater, especially as the water level rose over the long term. EPA states that oxidation (i.e., acidification) would be minimized as the pit filled. However, filling would take many decades; in any case, acidification would continue indefinitely (Eisler and Wiemeyer 2004). Although the quality of pit water varies widely, examples of toxic pit lakes are numerous (Braun 2002). (p. 10)
- Flocks of waterfowl regularly land in water bodies, including mine-created ones. Birds are unable to detect contamination when landing on hazardous ponds, and they may remain long enough to ingest lethal levels of acid and metals. Even if birds fly away before they are killed outright, internal injuries may reduce their survival under natural conditions (Hooper et al. 2007). In addition, tailings ponds may attract more birds if they incorporate "beaches" on their perimeter (EPA 2012, page 4-10). Although waterfowl often land in ponds with steep shorelines, the "beaches" will make the ponds accessible shorebirds and land birds. (p. 10)

<u>J.P. Tangen (Doc. #4583.1)</u>

- EPA's lack of design details makes its analysis of water collection and treatment failure events meaningless. The agency does not evaluate any specific failure modes or present data on similar failures at other mines. (p. 2)
- A pipeline may be required to develop a mine at Pebble, but no other mine in Alaska uses a pipeline. Because most mines do not use a pipeline, the predicted pipeline risks are unlikely to be representative of a mine other than at the Pebble Project in the Bristol Bay watershed. (p. 3)
- EPA's hypothetical pipeline omits obvious prevention and design strategies. In fact, some components of a mine are fixed and are difficult to change, but pipelines can be designed to different standards. It is unclear why EPA would design a pipeline with an unacceptable risk and not include design changes to decrease the risk. (p. 3)
- EPA came to a different conclusion for a potential mine pipeline at the Red Dog Mine where EPA recommended a pipeline. In that case the agency concluded that "it is highly unlikely that the pipelines would be compromised." (p. 3)

<u>Danielle Dawkins (Levelock Public Hearing)</u>

Natural disasters are unknowable, unstoppable and unpredictable in most cases. I ask that you please delve deeper into these natural occurrences and the potential it plays on the withstandings of the proposed pit, and things to be built, especially the seismic activity around the proposed Pebble site. It is my understanding that perhaps the fault lines run closer than what is illustrated in the figure 4-1 1 on page 4-42. (Levelock Public Hearing, p. 2)

Sheila Wehmeyer (Doc. #3486)

- The draft Assessment provides contradictory and conflicting information. For instance, Box 4-3 describes local faults and the known activity on those faults, and later describes the uncertainty in identifying fault locations and interpreting the frequency and distribution of earthquakes. Box 4-5 (paragraph 3) discusses earthquake effects, but notes that "Such displacement is not likely to occur in the Bristol Bay watershed because of the absence of large faults, but there is a potential for a small amount of ground spreading and cracking from larger earthquakes". This would seem to contradict with the final paragraph in Box 4-3, which emphasizes that there is a significant amount of uncertainty around predicting seismic activity in the Bristol Bay area. (p. 2 to 3)
- Section 4.4.3.1 assumes a 98% failure rate of pipelines associated with mining in the study area, and assumes that the total volume of the product with in a pipe would flow to ground in a failure scenario. This is unrealistic, as flow rates reduce during shut downs, reducing the volume spilled. (p. 3)
- Box 4-A presents four examples of catastrophic tailings dam and impoundment facility bank failures. None of these Case Histories are relevant to the regulatory requirements or construction techniques that would be expected for potential development at Pebble. (p. 4)
- 2/3 of report focuses on tailings facility failures, however, section 4.4.2 notes how few tailings facilities that may be similar to Pebble's have ever actually failed. (p. 4)

Gregory A. Beischer (Doc. #4372.1)

- The draft Assessment in part utilized sources with a known bias on projects in the study area. Claims by many of these sources have been found in Alaska courts to be unsubstantiated, and in one case claims by a cited source are refuted by other agency sources in Box 4-3 of the draft Assessment. (p. 2)
- The draft Assessment provides contradictory and conflicting information. For instance, Box 4-3 describes local faults and the known activity on those faults, and later describes the uncertainty in identifying fault locations and interpreting the frequency and distribution of earthquakes. Box 4-5 (paragraph 3) discusses earthquake effects, but notes that "Such displacement is not likely to occur in the Bristol Bay watershed because of the absence of large faults, but there is a potential for a small amount of ground spreading and cracking from larger earthquakes". This would seem to contradict with the final paragraph in Box 4-3, which emphasizes that there is a significant amount of uncertainty around predicting seismic activity in the Bristol Bay area. (p. 2)
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- Box 4-4 presents four examples of catastrophic tailings dam and impoundment facility bank failures. None of these Case Histories are relevant to the regulatory requirements or construction techniques that would be expected for potential development at Pebble. (p.3)

- 2/3 of report focuses on tailings facility failures, however, section 4.4.2 notes how few tailings facilities that may be similar to Pebble's have ever actually failed. (p. 4)

Stephen Gerdes (Doc. #4856)

- The effects of the construction of a roadway and pipeline paralleling Iliamna Bay and leading to the deepwater terminus. How many spawning streams would be affected? Would a rupture of one of the pipelines damage not only the immediate water shed but also the spawning grounds along the shoreline of Cook Inlet? What happens to the slurry water not returned to the mine site? What would be the potential toxic effect on Cook Inlet if not properly treated or contained? (p. 1)

e. OTHER

Sheila Wehmeyer (Doc. #3486)

- The draft Assessment in part utilized sources with a known bias on projects in the study area. Claims by many of these sources have been found in Alaska courts to be unsubstantiated, and in one case claims by a cited source are refuted by other agency sources in Box 4 - 3 of the draft Assessment. (p.2)

The Pebble Partnership (Doc. #4962)

- The Assessment is based on a hypothetical project, rather than an assessment of the watershed. The Assessment evaluated a hypothetical project with minimal mitigation of potential project effects. Therefore, the hypothetical project evaluated in this document is not simply a worse-case scenario; it is a very unrealistic scenario - a mining operation scenario that has not been permitted in the United States since late in the 19th or very early in the 20th century. Without engineering design and site-specific data, there is no technical way to accurately predict physical and chemical changes that could result in the natural systems. As a result, the Assessment is flawed and unusable. (p. 3)

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